OPERATIVE OTOLOGY

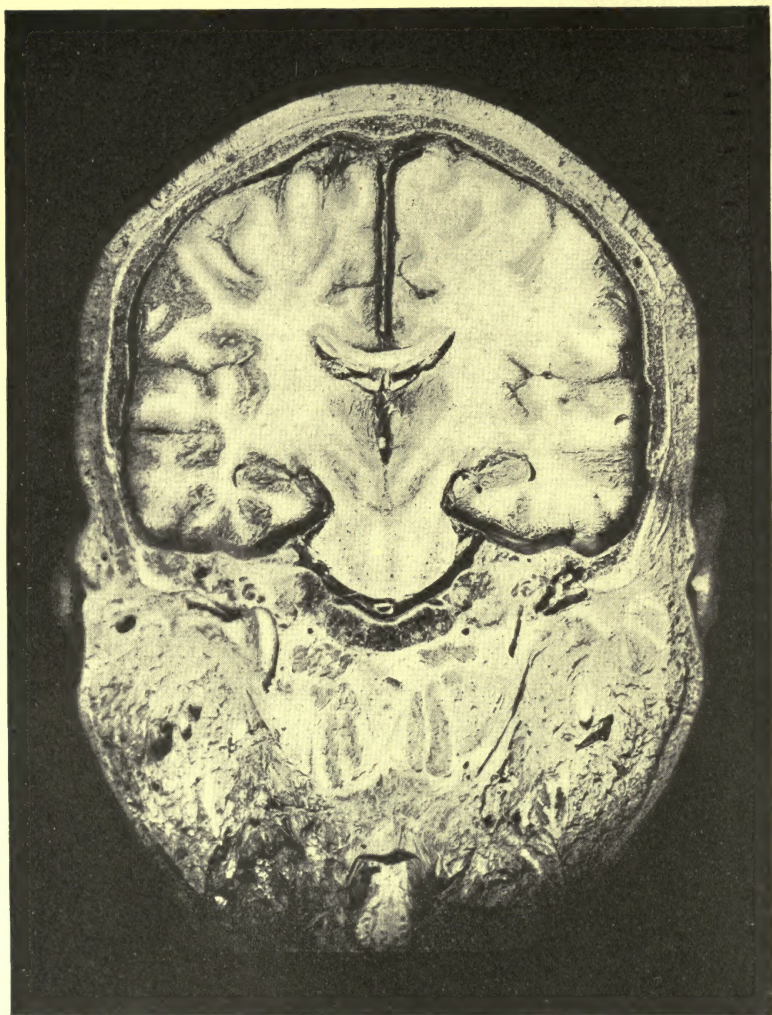## SURGICAL PATHOLOGY AND
TREATMENT OF DISEASES OF THE EAR

PLATE A.—PHOTOGRAPH OF CORONAL SECTION OF A FROZEN HEAD, PASSING THROUGH THE LEFT TYMPANUM ANTERIOR TO THE MALLEUS. Specimen preserved in the Anatomical Department of the Johns Hopkins University.

OPERATIVE OTOLOGY

SURGICAL PATHOLOGY AND
TREATMENT OF DISEASES OF THE EAR

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PREFACE

This book has been written in answer to questions asked in the class room, by the bedside, and in consultation, and is, therefore, intended for the use of the student, the general, and the special, practitioner.

As would be expected, from the character of its inception, it is rather the record of individual experience than a review of the literature of its subject, and has framed itself naturally upon those lines in which the majority of the questions have been asked, namely, the causative conditions of surgically remediable disease and the surgical measures best applicable to their treatment.

Essentially a surgical treatise, with a view to practical utility, structural descriptions have been limited to those of surgical importance, pathological conditions have been emphasized, and the detail of surgical procedure has been confined to that acceptedly applicable to the condition presented.

Two efforts have been consistently maintained throughout the work: one to present the given subject as simply as possible, the other to eliminate, as far as possible, that obstructive factor in scientific study—personal equation.

The illustrations are, mainly, original, from material at the authors' command; a few are copies from original drawings, made for Professor Politzer, and placed at the authors' disposal.

CONTENTS

CHAPTER I

SURGICAL ANATOMY OF THE TEMPORAL BONE AND ADNEXIA

CHAPTER II

ASEPTIC TECHNIQUE

CHAPTER III

DISEASES OF THE AURICLE AND EXTERNAL AUDITORY CANAL

CHAPTER IV

DISEASES OF THE TYMPANIC MEMBRANE AND TYMPANUM

CHAPTER V

THE POSSIBLE COMPLICATIONS AND CONSEQUENCES OF SUPPURATIVE OTITIS MEDIA

CHAPTER VI

MIDDLE-EAR OPERATIONS

CHAPTER VII

MASTOID OPERATIONS

CHAPTER VIII

ADVENTITIOUS AURAL SURGERY

APPENDIX

LIST OF FULL–PAGE PLATES

ix

LIST OF ILLUSTRATIONS IN TEXT

CHAPTER I

SURGICAL ANATOMY OF THE TEMPORAL BONE AND ADNEXIA

SURGICALLY considered, the temporal bone in the adult may be regarded as comprising three cavities, irregular in shape but definite in individual form, surrounded by cortical bone the two layers of which either approximate to the point of fusion or are separated by diploë. Of these cavities, the labyrinth and tympanum contain structures for the molar and for the molar and molecular, transmission of sound waves, and for the determination of grosser movement incident to the maintenance of equilibrium; the third cavity, that of the mastoid, being, in effect, a continuation of the tympanum, with the addition of a comparatively excessive degree of development of the diploetic substance.

The first of these cavities is completely developed at birth, and the second almost so, while the third, consisting at first merely of a blind prolongation, posteriorly, of the tympanum, gradually develops and extends backward and outward until, at the termination of primary adolescence, it has attained the limit of extension, which it retains through adult life, as the mastoid process of the temporal bone.

LABYRINTH

Considering these cavities in order from within outward, the labyrinth is the most distinctive; it is inclosed within its own bony wall, and surrounded by a layer of diploë of the petrous portion of the temporal bone, which, even in adult life, does not entirely disappear; it is the most completely encapsulated of the three cavities, devoted in its anterior portion to the lodgment of the apparatus for the transmission and reception of sonorous vibrations, and in its posterior portion to the apparatus for the perception of the grosser modes of motion as a peripheral organ of equilibration. It has three afferent and two efferent openings. The afferent openings in the capsule wall are the porous acousticus internus, its walls a prolongation of the labyrinthine capsule, for the passage of the auditory and facial nerves, the opening of the oval window, closed by membrane and by the base plate of the stapes, and the round window, closed by membrane alone. The efferent openings are the aqueduct of the cochlea and the aqueduct of the vestibule. The auditory nerve, branching at the fundus of the porous acousticus internus, is distributed to the contents of the labyrinthine capsule; but the facial nerve, entering at the same point a channel of its own with distinct cortical walls, passes through the diploë of the petrous portion of the temporal bone, at first forward, then sharply backward over the niche wall of the oval window, downward and outward beneath the inner and lower cortical walls of the antrum, and then downward to make its exit at the stylomastoid foramen, giving off, in the median part of its course, in addition to various

sympathetic connections, principally with the vidian, a twig to the stapedius muscle, and a branch, the chorda tympani, which, crossing the tympanum partly below the lower border of the epitympanum and passing between the long process of the incus and malleus, makes its exit at the anterior tympanal fissure, for distribution mainly to the anterior and lateral portions of the tongue.

Encapsulated as it is, the labyrinthine cavity is but little subject to pyogenic invasion through its cortical walls, as is shown by its sequestral separation as a whole, or in large portions, in the event of extensive necrosis of the petrous portion of the temporal bone,[1] the concurrence of its membranous contents in a septic process being mainly due to invasion through some of its afferent openings.

The protection afforded, however, by the resistant action of the soft tissues closing these channels of possible invasion is such that suppurative implication of the labyrinthine contents is a rare occurrence.

The position of the labyrinth, forming, as it does, a portion of the inner tympanic wall, makes it readily accessible to surgical interference, either directly through the external auditory canal, or posteriorly through the base of the petrous portion of the temporal bone, when that region has been exposed by an operation upon the mastoid; while the position of the facial nerve, close to the cortical wall of the tympanum above the oval window, on the floor of the antrum, and juxtaposition to the posterior tympanic wall, where the cavity of the pyramid for lodg-

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[1] The larger sequestra usually include the cochlea and anterior portion of the vestibule, the line of separation passing through the oval and round windows.

ment of the belly of the stapedius muscle approaches it, present vulnerable points which should be regarded in intratympanic, mastoid, and tympanomastoid operations.

Surgically, the labyrinth may be regarded as a fixed factor, whether interference is demanded in infantile or

Fig. 1.—Photographic enlargement of tympanic area; same specimen as shown in Plate A. Showing, in addition to the size and contents of the tympanum, the pneumatic structure of the tegmen tympani and antri, whorl of the cochlea, carotid canal, tympanopharyngeal tube, and external auditory canal.

in adult life; it is fully developed at time of birth, and remains practically unchanged in contour and in surroundings except for the gradual condensation of the diploë of the petrous bone.

TYMPANUM

Very different is the surgical aspect of the next outermost cavity, the tympanum, with its extension in the external auditory canal toward the surface, and in the pneu-

FIG. 2.—Same specimen as in Fig. 1, photographed after disarticulation of malleus and incus and the forcing outward of the malleus and tympanic membrane; showing more distinctly the individual ossicles and the nature of the bone separating the tympanic from the cranial cavity.

matic cells of the mastoid, posteriorly, with an additional opening anteriorly into the tympanopharyngeal tube, which establishes for it a free communication with the nasopharynx (Fig. 1).

But two elements of this cavity may be regarded, surgically, as fixed factors: its inner wall, practically the outermost wall of the labyrinthine capsule, and that portion of its contents constituting the hyordean series, and comprising the three auditory ossicles, substantially the same in size, contour, and relation at birth as in adult life, and changing only in their interior structure by the gradual increase in thickness of their cortical substance (Fig. 2).

The tympanopharyngeal tube, opening into the tympanum on its anterior wall, and bounded superiorly by the curved bony plate which partially incloses the belly of the tensor tympani muscle, narrows forward to the point of its junction with the membranous portion of the tube, this portion being cartilaginous on the posterior and superior, and membranous on the anterior and inferior walls; the cartilage projecting, in the adult, into the nasopharyngeal space as a distinct elevation on the lateral
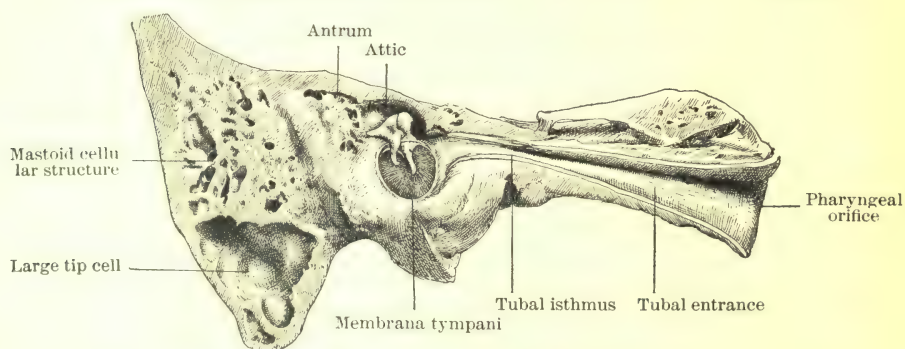
FIG. 3.—Illustrating relationship between the tympanopharyngeal tube, tympanum, antrum, and mastoid cells.

pharyngeal wall (Fig. 3). The general direction of the membrano-cartilaginous tube, from its point of junction with the osseous portion, is downward into the naso-

pharynx at an angle of forty-five degrees, in the adult; but in the infant and young child this portion of the tube is more horizontal in position, more patulous, and lacks the boss of cartilage projecting into the nasopharynx. Tactile examination of the nasopharynx, in the adult, clearly reveals this cartilaginous projection at the posterior border of the triangular-shaped faucial opening of the tube; and its absence, or moderate degree of projection, in young children, explains the readiness with which the tubal opening may be occluded by lateral enlargement of the pharyngeal tonsil extending downward in the post-tubal fossa.

In the infant, the tympanum, though nearly developed, is not a completely inclosed bony chamber, as it comes to be in the adult, with the exception of the persistent opening outward, closed by the membrana tympanum, and the two persistent openings inward, closed by the membrane of the oval and round windows. The osseous external auditory canal is represented in the infant only by the annulus tympanicus, lying with its plane very nearly horizontal, and with, not infrequently, dehiscence of bone on its outer posterior margin; the sutural union of the different parts of the chronosteon is loose, and filled in by soft tissues, and the bone itself, with the exception of the already developed labyrinth capsule and the ossicular chain, is soft and highly vascular. The development of the osseous external auditory canal, which proceeds from the extension of the annulus tympanicus outward conjointly with the projection outward of the lower squamous plate of the temporal bone, the upper plate contributing to the formation of the tegmen tympani, and the apical portion of the resultant intervening space being filled with

diploë, and with the development of the mastoid process, still leaves, in some cases, dehiscence of bone on the posterior margin of the original annulus, on the posterior wall of the tympanum into the nerviduct of the facial, in the tegmen tympani and tegmen mastoidea, which may need to be borne in mind.

At two years of age the sutural connections of the tem-

Fig. 4.—External aspect of temporal bone at two years of age.

poral bone have become firmly established; the petrosquamous fissure has been practically obliterated, the annulus tympanicus projecting outward from below has assumed the constant position of its plane at an angle of forty-five degrees to the long axis to the now established osseous external auditory canal, and the mastoid process

proper is represented by a small superficial têtelike projection downward, partially concealing the digastric fossa (Fig. 4).

Anteriorly to the tympanic cavity, and separated from it by a firm cortical wall in both the child and the adult, lies the internal carotid artery; and posteriorly to the mastoid extension of the tympanum, likewise separated by a firm cortical wall, lies a large vein, the continuation of the internal jugular in the lateral sinus, these being the two vessels most important for the consideration of the aural surgeon in connection with operation upon the bony envelope of the auditory apparatus. The cortical wall of the carotid canal is perforated by an opening, or openings, of inconstant location, for the passage of branches supplying mainly the lining membrane of the epitympanum and upper portion of the membrana tympani, while a mastoid emissary vein, or veins of equally variable location, connect with the sinus.

While the soft tissues of the tympanum remain virtually the same in the adult as in the child, except as regards their lessening vascularity, the external auditory canal changes both in its contour and in its constituency. At first, in the infant, a merely membranous canal with lax and sometimes apposing walls, and perforated with transverse fissures lightly clothed by fibrous tissue, it becomes, in the adult, in its inner portion bony, while the outer and now more distinctly cartilaginous portion becomes more firm, and its transverse fissures smaller and more completely bridged by fibrous tissue. In its general direction, in the adult, the canal trends, in its outer or cartilaginous portion, inward, downward, and forward, the junction between the two portions being formed by fibrous

tissue and a perichondrium continuous with the periosteal lining. At its outer end the cartilaginous tube extends into the pinna, which only partially represents the contour of the auricle as a whole, the remainder being made up by reduplication of the enveloping skin with intermediate layers of fibrous and fatty tissue, as is most distinctly seen in the lobule.

Soft Tissues.—Aside from its basal tissues, the structures connected with the auricle which may be of importance surgically are its extensive muscles of support and attachment, the attolens, attrahens, and retrahens auren, its intrinsic muscles helicis major and minor, tragicus and antitragicus, virtually rudimentary, but which may play a distorting part in the repair of wounds or other injuries of the auricle and its blood supply, mainly from the anterior auricular branch of the temporal artery, with a branch along the superior wall of the external auditory canal, and the posterior auricular branch of the occipital artery with their auricular anastomosis.

The skin covering the elastic layer of the auricle is firmly attached by fibrous tissue to the perichondrium on the lateral external surface, and is wanting in fatty tissue. On the inner medial surface the skin is movable, the epidermis thicker, with a subcutaneous fatty layer, and increasingly beset, toward and into the meatus, with hair, sudoriparous, sebaceous, and ceruminous glands, which do not extend, however, inward much beyond the outer third of the canal; from the point of their cessation the skin becomes progressively thinner and more closely attached to the periosteal lining of the canal, until finally, as a layer of permanent epithelium, it forms the outer or dermoid coat of the membrana tympani.

TYMPANIC MEMBRANE.—This composite membrane constituting the boundary between the outer and middle ear, so called, consists of a membrana propria formed of two layers of fibrous tissue. The general direction of the fibers in the outer layer is more uniform than that in the inner layer, in which the fibers are massed just within the periphery of the membrane, constituting, with the outer fibrous layer, a vibrating membrane increasing in thickness from the center toward the periphery, but thin immediately within the periphery, where the expansion of the radiating fibers is firmly inserted in the irregular sulcus of the tympanic ring (Plate B).

The inner coat of the membrana tympani resembles the outer coat, in that it is the continuation of a lining membrane, likewise reduced to a pavement epithelium, where it is reflected upon the membrane, the mucous lining of the tympanic cavity.

As the result of its structure and its attachments, this membrane, instead of a plane surface, presents one depressed at its center, and variably convex from the center to the periphery, the greatest convexity being in the anterior and interior segment, and the least in the posterior segment, where the two fibrous layers are supplemented by a third delicate dendritic fibrous layer of variable extent. The position of the membrane, as a whole, to the long axis of the osseous portion of the external auditory canal, is such that it forms an acute angle with the anterior and inferior canal walls, and an obtuse angle with the posterior and superior walls.

Above this membrane, properly called the membrana vibrans, because of its function in the reception and transmission of sound waves, to which it sympathetically

responds because of its form and structure, in a much
wider range of tone than would be possible if it were a
plane membrane, there is situated a thin membrane formed
by a continuation of the dermoid and mucous layers of
the membrana vibrans with little or no interposed fibrous
tissue. This membrane, the pars flaccida, is bounded
by the anterior and posterior striæ of the short process
of the malleus, and by the process itself, laterally by the
ends of the incomplete annulus tympanicus, and supe-
riorly by the outward projection of the outer plate of the
squamous portion of the temporal bone. The membrane
is normally imperforate, and forms the outermost bound-
ary of the incisura epitympanica, as does the membrana
vibrans of the tympanic cavity.

OSSICLES.—The first bone of the ossicle chain, the
malleus, is inserted by its long process between the
layers of the membrana vibrans (Fig. 5) in such manner
as to give a moderate freedom of motion in its relation to
that membrane both laterally and vertically, by turning
upon its long axis. These two movements are capable of
being conjointly executed, but the greatest freedom of
movement laterally is that which carries the short process
of the malleus forward; vertically it is that which carries
the long process of the malleus inward and upward, and
projects the short process downward and outward, both
of these directions of movements being executed, in their
greatest degree, under the traction of the tensor tympani
muscle, which is attached to a small bony projection on
the inner surface of the malleus just below the upper
limit of the long process and slightly anterior to its
median line.

The head of the malleus, united to the long and short
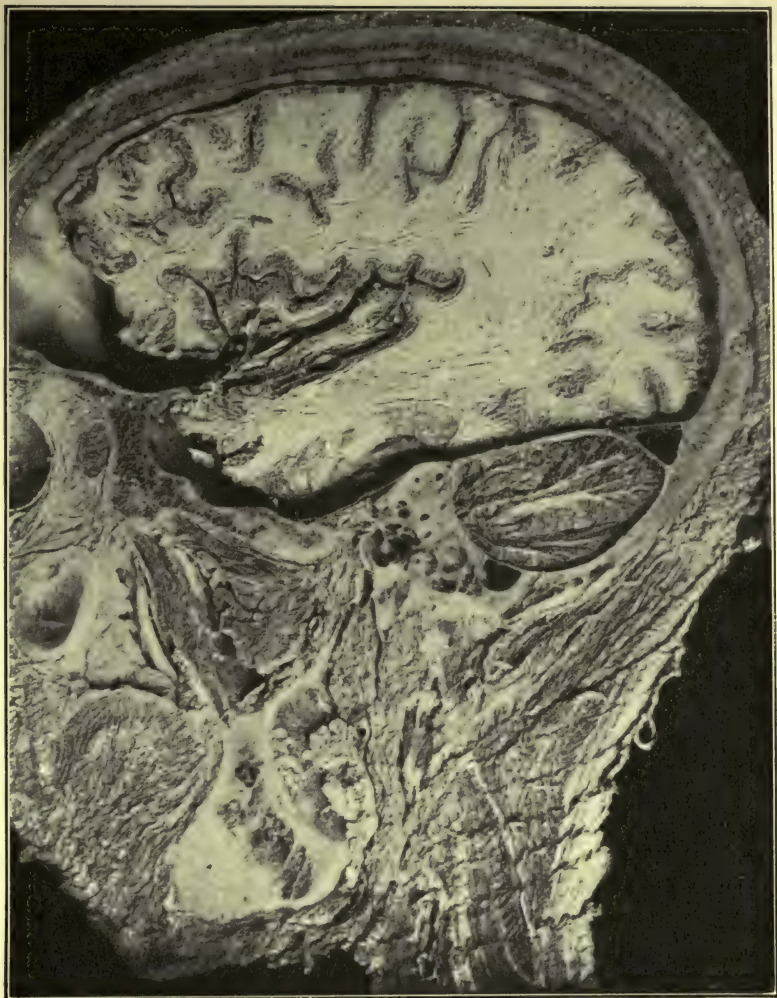
PLATE B.—Sagittal Section of Frozen Head, Through the Right Tympanum, Showing Tympanic Membrane and Ossicles as Viewed from Within. Specimen in the Anatomical Department of the Johns Hopkins University.

processes by a short neck, is ovoid in shape, with exception of its posterior aspect, which presents two obtuse-angled facets for articulation, with corresponding facets on the anterior face of the body of the incus, and a bony projection, or lip, below the facets, which favors closer interlocking of the joints, so that a major contraction of the inner tympanic muscles brings it into contact with the lower border of the facetal face of the incus.
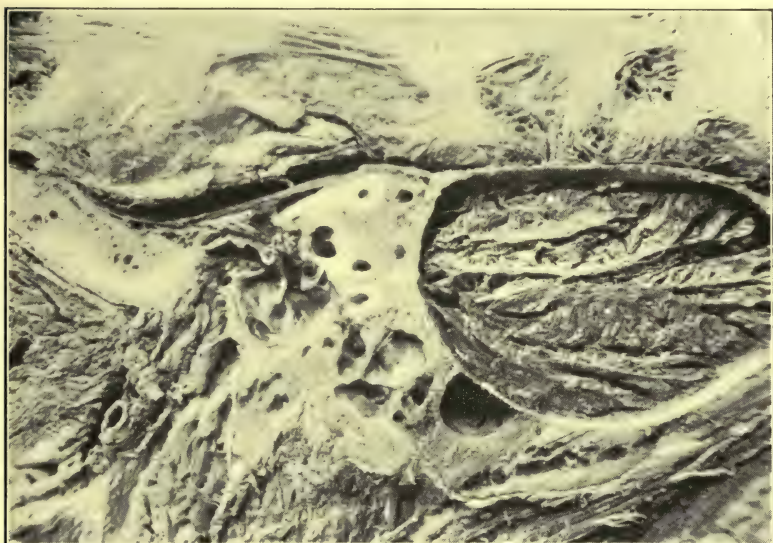
Fig. 5.—Photographic enlargement of tympanic area of same specimen; also showing relationship of tympanum to cerebellum, sigmoid sinus, and particularly the dural layer separating it from the cerebrum.

The incus, articulating posteriorly with the malleus by a true joint, comprising cartilage, a cartilaginous meniscus, synovial membrane, and a capsular ligament, is placed with the long axis of its body at right angles to the long axis of the head of the malleus, the body terminating posteriorly in a conical extension attached by a fan-shaped ligament radiating from the apex of the bone

to the walls of the niche in the posterior portion of the outer epitympanic wall. From the anterior portion of the body of the incus its long process extends downward, very nearly parallel to the long process of the malleus, terminating in a narrow neck very nearly at a right angle to the long axis of the process, and enlarging into an ovoid expansion for articulation, being also a true joint in its possession of cartilage, synovial membrane, and ligamentous environment.

The stapes consists of a head with a shallow depression for articulation, two crura lying very nearly in a horizontal plane and terminating within the limit, antero-posteriorly, of a reniform base plate, placed with its long axis very nearly horizontal and its convex border uppermost with the margin of the oval window, to which it is attached by the double layer of fibrous tissue constituting the basal membrane of the oval window under conditions permitting a greater freedom of motion anteriorly than posteriorly. The base plate of the stapes is covered on its inner surface by a thin cartilage, which, with the annular cartilage of the oval window and intermediate synovial membrane, afford, in this final articulation of the ossicular chain, also the histological characteristics of a true joint.

Attached to the posterior surface of the head of the stapes, and partly to the capsular ligaments of the joint, with occasional fibers extending into the tip of the descending process of the incus, is the tendon of the stapedial muscle emerging from the tip of the posteriorly situated cone-shaped cavity, eminentia stapedia, which lodges the belly of the muscle, a cavity usually separated from the nerviduct of the facial, toward which it curves posteriorly,

by the distinct bony lamella of the cortical canal wall, though at this point there is in some cases a dehiscence of bone (Fig. 6).

Examination of the ossicles on section shows them to be formed of firm cortical bone of varying degrees of thickness, the intermediate space being filled by bone of lesser density permeated by intercommunicating medullary canals. These canals are larger and more numerous
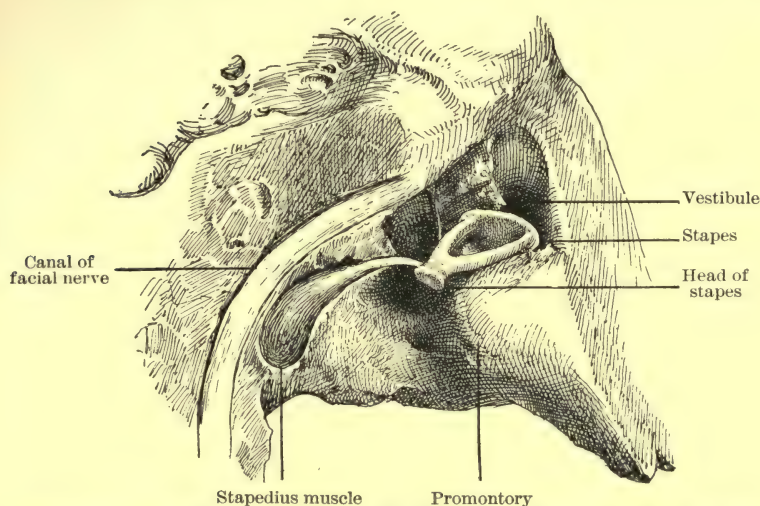
FIG. 6.—Internal wall of tympanum, the Fallopian canal and vestibule opened.

in the more expanded parts of the ossicles, the head of the malleus, body of the incus, the bases of their processes, and the expansion of the long process of the malleus, than where the cortical walls more nearly approximate. In the head of the stapes they enlarge into one or more distinct cavities.

The periosteal covering of the ossicles being intimately connected with the superimposed submucous lining of the tympanic cavity, the vulnerability of the medullary struc-

ture to a necrotic process incident to septic infective inflammation in the tympanum is greatest where the cortical wall is thin and the medullary channels more nearly approach the surface, these points being the articulating facets of the malleus and incus, the lower portion of the long process of the malleus, which has on its outer surface and inclosing its tips a cartilaginous covering, the apex of the short process of the incus and the head of the stapes; the crura are more resistant to a necrotic process, because of the thickness of their cortical walls and the small amount of intercortical medullary structure. The principal attachments of the ossicles are the anterior ligaments of the malleus, inserted about the remnantal base of the processus gracilis, its cells a survival of the anterior mandibular process of the embryonic cartilage; the capsular ligament of the malleoincudal articulation; the posterior fan-shaped ligament of the incus; the suspensory ligament of the malleus and incus, varyingly constant in degree and function; the external ligament of the malleus, bounded superiorly by that portion of the epitympanic space, above the short process of the malleus, which is inclosed inferiorly and externally by the pars flaccida; and various ligamentous striæ situated especially between the two major ossicles and the contiguous outer epitympanic walls. In addition, there are in varying degree and location, but more especially in the plane separating the tympanic from the epitympanic space, reduplications of mucous membrane, frequently with fibrous lamination, the division of which also may have to be considered in operations for removal of the ossicles, it being advisable to free these bones as completely as possible from their attachment to the bony tympanic walls,

or to the tympanic membrane, before effecting their removal.

In all operations within the tympanum, and similarly within the mastoid, the contour of the inclosing walls and the significance of the structures beyond them should be kept constantly in mind; a distinct mental picture of contour and of relationship being more important to the aural surgeon than the mental enumeration of distances between given points, and the possession of a concept of normal configuration the best basis
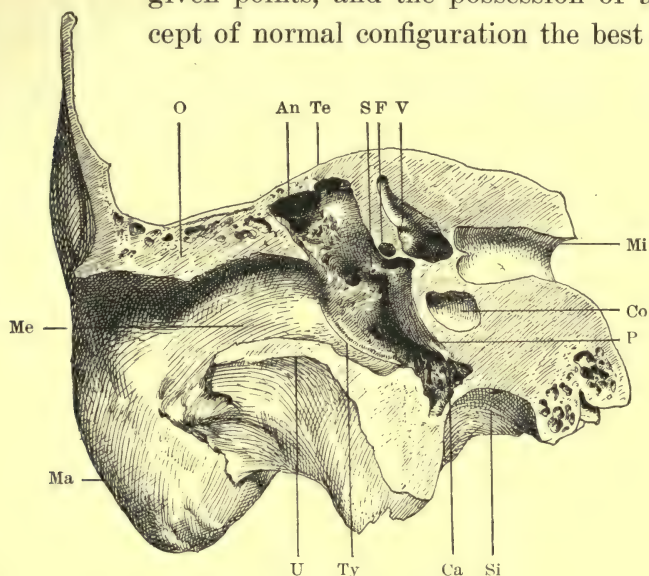
FIG. 7.—Lateral section through the tympanum and auditory canals; ossicles and soft parts removed. Relative size of the epitympanum well shown: *Ma*, mastoid process; *Me*, external auditory canal; *Mi*, internal auditory canal; *Co*, cochlea; *P*, promontory; *V*, vestibule; *F*, canal of facial nerve; *S*, point of attachment of stapedius muscle; *Te*, roof of antrum; *An*, antrum; *Ty*, tympanic ring.

from which to contemplate the sequence of possible anomaly (Fig. 7). To be able to get into the tympanum or mastoid and view its walls from within is a valuable attitude from which to approach the details of an operation.

3

Fully one third of the tympanic space lies above the limit of the superior periphery of the membrana vibrans, this estimate not including the extension forward into the tympanic end of the tympanopharyngeal tube and backward into the tympanic antrum. Because of the varying size of the extension and the flattening or arching of the tegmen tympani, the dimensions of the epitympanic space are more variable than the contour of the more constant space below it would indicate. In the case of intratympanic operation in suppurative diseases this fact emphasizes the importance of careful tactile examination of the epitympanic walls, when access thereto has been accorded by spontaneous or operative evulsion of the major part of the ossicular chain, and, if necessary, the removal of the outer epitympanic wall at the point opposite the depression for lodgment of the body of the incus, where the bone is thin.

Viewed from within, the inner tympanic wall presents a prominence curving sharply backward into the anterior wall of the niche of the oval window and to the anterior border of the bony ring surrounding the round window; within this projection is lodged a portion of the first whorl of the cochlea and the anterior portion of the vestibule, and it presents the most accessible point for openings of the labyrinth in cases of suppuration within that cavity. Downward from the promontory the inner wall curves sharply inward, more completely defining that projection called the promontory, and then downward and outward to form the tympanic floor, beset by bony trabeculæ, which run mainly from within outward and furnish a ready vulnerable seat for limited necrotic processes. Upward, the inner wall, in its anterior portion, bends

sharply outward in the bony plate, above which is lodged the belly of the tensor tympani muscle, while in its posterior portion its trend is upward and backward, to merge into the epitympanic roof and form the inner wall of the tympanic antrum. The anterior wall, more moderately beset with trabeculæ, curves moderately upward into the tympanic flare of the tympanopharyngeal tube. The posterior wall, also beset with trabeculæ in its lower portion, and presenting the later irregularities of contour because of the projection forward into the tympanum of the eminentia stapedii, and the extension backward from the tympanum of variable pneumatic prolongations, curves upward and then backward, to merge into the floor of the tympanic antrum.

The outer epitympanic wall, above the superior periphery of the membrana vibrans, presents a smooth, slightly concave surface, in the lower portion of which are lodged the head of the malleus and body of the incus, the upper portion curving inward to join the tegmen tympani superior, and posteriorly to join the inner wall of the tympanic antrum, below which the concaved surface dips into the recess for lodgment of the tip of the body of the incus, a depression extending posteriorly toward the mastoid in varying degree, and capable of affording lodgment to septic products of an intratympanic inflammation.

MASTOID

The third of the cavities of the temporal bone bespeaking surgical attention is the last to attain complete development; its extension from a pneumatic projection of the tympanic antrum backward, in the infant, to its completion as the largest and most superficial of the three primal

cavities of the chronosteon, covering a period between birth and the termination of primary adolescence, and being marked by progressive changes in the contour, relationship, and the bony structure of the mastoid.

Sections of the tympanum and post-tympanal bone, made successionally at different ages in the infant, show first an expansion of the post-tympanal bone outward on the posterior superior periphery of the annulus tympanicus, the space within being devoted to the enlargement, outward and backward, of the tympanic antrum, or its continuation in pneumatic cells, which still further extend, coincidently with the expansions of the mastoid cortical wall, by the building up of bony trabeculæ or the more extensive cell walls, about which the diploë forms by a similar intermediate process of expansion. The bony tissue separating and surrounding the pneumatic and diploetic cells is, in the infant, very vascular, soft, friable, protected by the corresponding vascularity of its surrounding soft tissues, but, when once invaded by a septic process, little able to withstand or to limit it; the frequency of post-aural abscess and of progressive interlamellar osteomyelitis of the post-tympanal bone and squama, as a sequence of suppuration within the middle ear in the infant, being accounted for by the loose relationship of the individual bony parts, later joined by cortical extension and the nascent condition of the bone itself.

At or soon after the termination of the infantile period, the interior of the mastoid process is developed, so far as the proportion of its integral parts is concerned, and the type, like the type of the cranial bones proper and of the cranium as a whole, is established. From this period of life onward to the end of primary adolescence the mas-
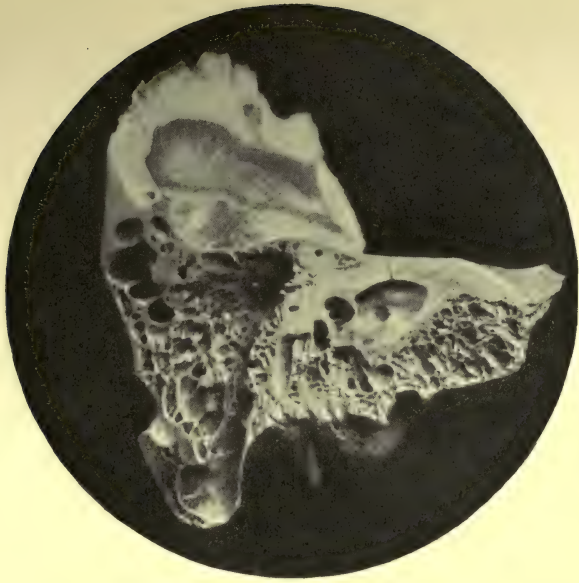
PLATE C.—Types of Pneumatic Mastoids.
(Photographed from specimens in the Harvard University collection.)

toid process enlarges by expansion, mainly outward and downward; its outer cortical surface either becomes more rounded, or extends farther backward, covering posteriorly situated pneumatic cells, and the mastoid tip, sometimes principally diploetic in its contents, but oftener comprising a continuation of the pneumatic cells, projects sufficiently below the digastric fossa to afford a considerable surface for the attachment of the tendon of the innermost segment of the sternocleidomastoid muscle.

While the progressive developmental changes in the mastoid cavity and its cortical walls present a certain
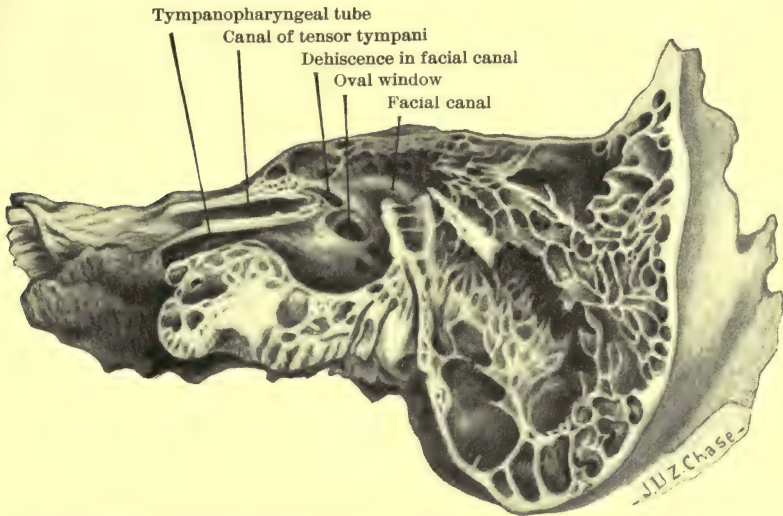
Fig. 8.—Extreme type of pneumatic mastoid. Section showing inner wall of tympanum and antrum.
(Drawn from specimens in the Wistar Institute of Anatomy.)

definable sequence, a comparison of the developed mastoid in different adult individuals (Fig. 8) shows such differences in contour and in structure as to justify the assertion that there is no one bony structure in the human body which presents so many deviations, both in its inclos-

ing walls and in its interior, from an arbitrary standard type, as does the normal mastoid process of the temporal bone (Fig. 9); and when its juxtaposition to the cranial cavity is considered, there is none in which these varia-
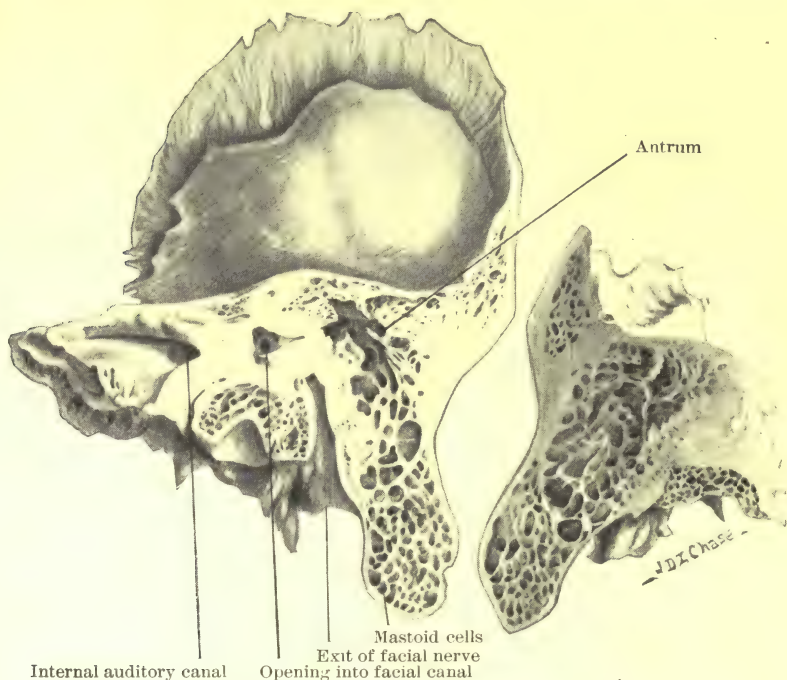
FIG. 9.—Section through an elongated, pneumatic mastoid.
(Drawn from specimens in the Wistar Institute of Anatomy.)

tions may have so important a bearing upon the welfare of the individual in the event of its becoming the seat of a morbid process.

The outer surface of the mastoid, for instance, may be flattened or rounded in its contour; it may be bounded interiorly by a well-marked digastric fossa, or may merge its outline, with only a shallow depression, into the surface of the posterior articulating portion of the temporal bone. On its anterior surface it may either boldly define
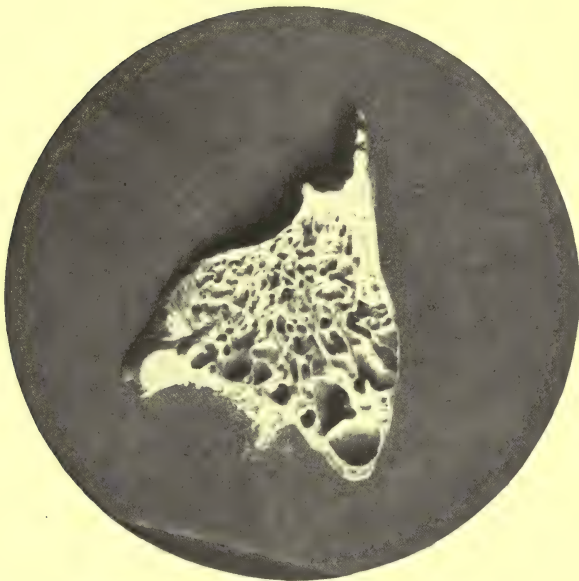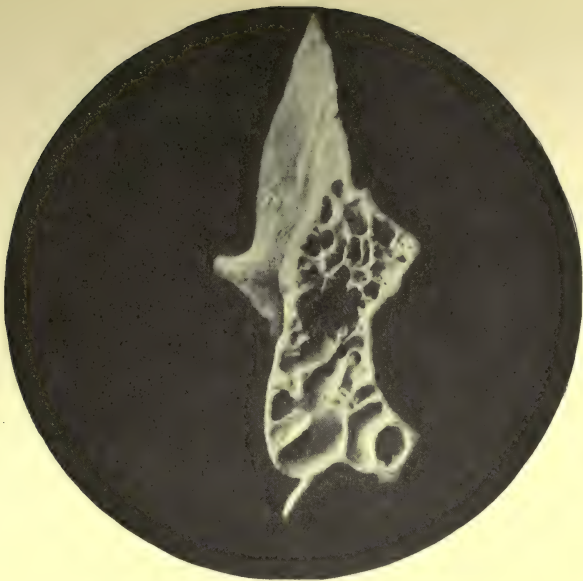
PLATE D.—Types of Pneumatic Mastoids.
(Photographed from specimens in the Harvard University collection.)

the posterior wall of the external auditory canal, or may
trend toward it in a gradual incline at an angle of forty-
five degrees from the median vertical line of the mastoid
protuberance.   In like measure the thickness of the corti-
cal wall is subject to very considerable variations, both as
to degree and location (Fig. 10).   The outer wall may be
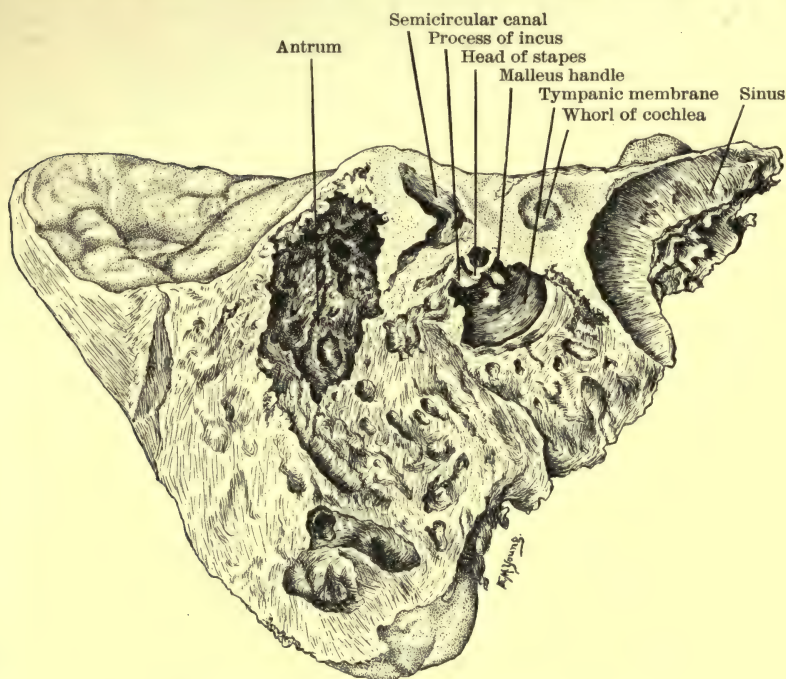
Fig. 10.—Outer walls of antrum and tympanum.

in places as thin as ordinary writing paper, or so thick
throughout as to occupy one third of the horizontal depth
of the cavity; it may be firm and compact, or permeated
by numerous small openings for the passage of vessels,
and the regions of the tip of the mastoid, and of the
digastric fossa, are liable to present many variations in
thickness within a very circumscribed area, the bone at

this portion of the mastoid being often so thin as to be almost transparent in limited areas, and for small spaces even entirely wanting. The same multiplicity of variations as to the contour of the bone, its density and thickness, is found on examination of the inner walls separating the mastoid from the cranial cavity; the sinus may encroach boldly upon the space otherwise occupied by the mastoid cells; it may be shallow and situated posteriorly, or well-defined and curving sharply forward, in its upper portion, toward the mastoid antrum; and small and circumscribed areas of thin bone, or even of lacunæ, may be found here, as well as upon the outer surface.

With such variations, the establishment of any general rule as to correspondence in contour between the inner and the outer mastoid walls, and differences in thickness in the cortical bone, is practically impossible, though it may be generally accepted as an axiom that where the outer presenting wall normally is thick, thin bone will be found at the mastoid tip and in the digastric fossa.

The question of symmetry in the two mastoid processes in an individual is sometimes of importance, where one mastoid is diseased, but the general rule of symmetrical development is supported by the fact that marked asymmetry of the two mastoid processes occurs, on the average, in less than four per cent.[1]

In the event of disease of one mastoid, with considerable swelling of the superincumbent soft tissues, a super-

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[1] Of 300 crania examined with reference to this point, 10, or three and one third per cent, had markedly asymmetric mastoid processes. When the mastoid process was small, or the digastric fossa deep, the lateral sinus was deep, and curved sharply toward the antrum in eighty-two per cent of the crania. Of the total of 300 crania examined, 62, or twenty-two per cent, had either a small mastoid or deep digastric fossa with deep lateral sinus.
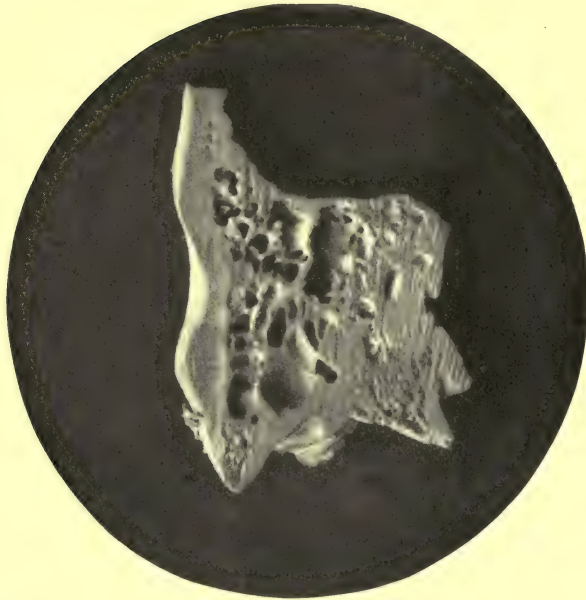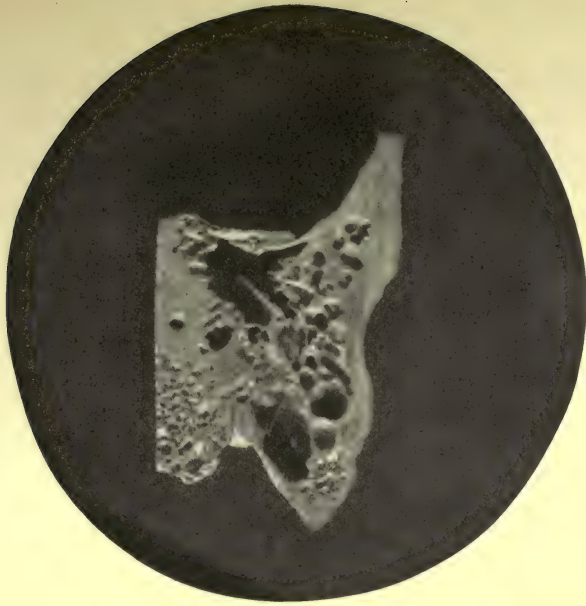
PLATE E.—A Type of Mastoid Between the Pronounced Pneumatic and the Diploetic.
(Photographed from specimens in the Harvard University collection.)

ficial tactile examination of the corresponding bone of the other side may, in view of this observed fact, afford information with reference to the conduct of a surgical procedure upon the affected side.

The variations in contour of the outer walls of the adult normal mastoid are quite equaled in diversity by the differences in size, shape, and arrangement of the subdivisions of the contained space, and, in addition, by the relations of this mastoid space to the mastoid antrum and middle ear.

At its upper and posterior portion the tympanic cavity extends backward, in the aditus ad antrum mastoideum, the curve, still backward and slightly outward in the mastoid antrum, representing, in the newborn infant, with the addition of a few cellular spaces superiorposteriorly, the beginning of the mastoid cavity, later developing downward and outward and forming a supplementary portion of the posterior wall of the external auditory canal. During the first twelve months after birth the cellular formation proceeds, especially in the upper and outer portions of what is to be the base of the inverted pyramid of the mastoid proper, and after this period the development and proliferation, as it were, of the cells, downward and outward progresses, with a greater degree of difference in rapidity, in extent, and in the relationships of the cell than is found in the development of the outer cortical portions of the mastoid.

The mastoid process does not consist entirely of pneumatic cells continuous from the antrum, but frequently in part, and occasionally wholly, of diploetic substance, the pneumatic cells in the latter instance being few in number and confined to the neighborhood of the antrum. In

some cases, also, the diploë is found only at the superior portion and at the tip of the mastoid, while in other cases it entirely surrounds a few centrally situated pneumatic cells.[1]

Instead of extending downward only from the mastoid antrum, the pneumatic cells occasionally extend upward and backward between the outer and inner cortical layers of the squamous portion of the temporal bone, occasionally to such an extent as to make the sum of their contained area equivalent to one third of that of the mastoid proper. In like manner the pneumatic cells, in about three per cent of all temporal bones examined, extend backward beyond the posterior superior limit of the mastoid in varying degree, occasionally to the limit, posteriorly, of the temporal bone, the outermost cell impinging upon the cortical surface of the suture.

The mastoid antrum also shows great variation in its size and position, in some cases narrowing toward the point at which it passes over into the pneumatic cell spaces of the mastoid, in others projecting upward into the pneumatic cell space of the upper mastoid portion, as a direct continuation of the tympanic cavity backward, from which the pneumatic cell spaces diverge downward through a small primary opening. The lining membrane of the middle ear, which in the fœtus projects into the mastoid antrum as a pouch or invagination, is in both the

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[1] According to Zuckerkandl, in 36.8 per cent of the cases examined by him, the mastoid consisted, from its upper point to its lower boundary, of larger or smaller pneumatic spaces; in 43.2 per cent it was formed, chiefly in its lower and posterior portion, of diploetic and osseous substance; while the anterior superior part contained pneumatic cell spaces; in twenty per cent the mastoid was wholly made up of diploetic, less frequently of sclerotic, tissue.
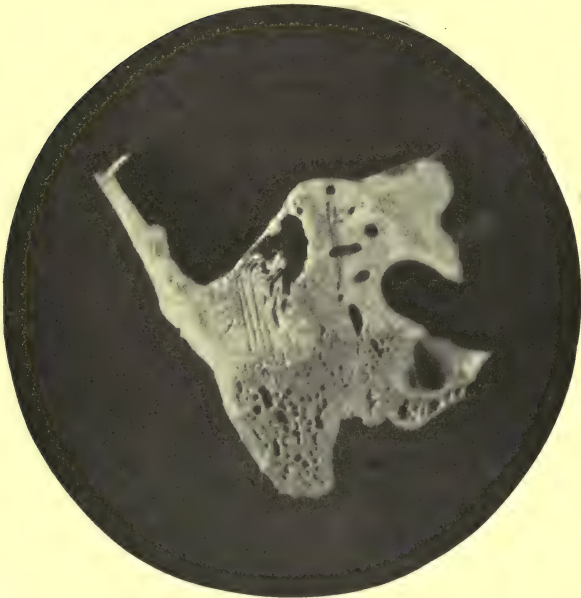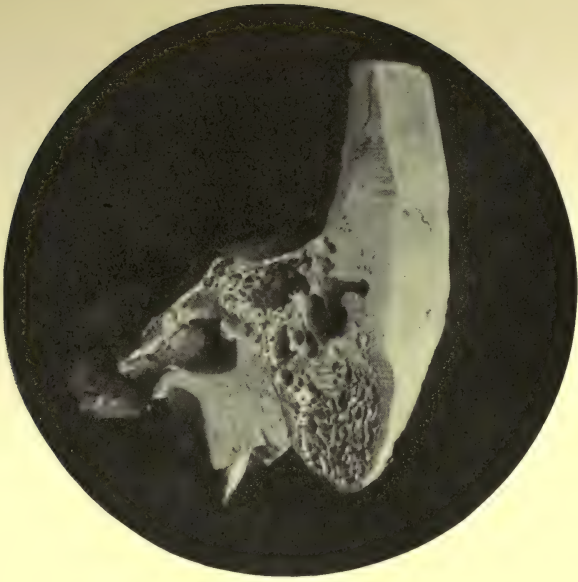
PLATE F.—TYPES OF DIPLOETIC MASTOID.
(Photographed from specimens in the Harvard University collection.)

child and the adult continued into the mastoid cells as a highly vascular, nonciliated pavement epithelium, serving, in both the pneumatic and diploetic spaces, the double purpose of lining membrane and periosteum.

In the mastoid antrum of both the child and the adult this membrane is thicker and more vascular than in other portions of the mastoid, affording, with the reduplications and striæ here found crossing the lumen of the opening beyond the aditus, a means for the closure of the mastoid from the tympanic cavity, under conditions of sudden or prolonged congestion.

Another normal condition of the soft tissues in the upper portion of the tympanic cavity which may play an important part in mastoid disease is the occurrence, in about eighty per cent of all human temporal bones, of reduplications of the lining mucous membrane situated in the horizontal plane, often in two or three strata, the lowest seldom or never below the tendon of the tensor tympani, and the highest not much above the upper border of the head of the malleus. These horizontal folds, or reduplications, are usually firmer and more complete in the posterior portion of the tympanum, and serve, by shutting off the lower portion of that cavity, to make the upper portion practically a tympanic supplement to the aditus ad antrum mastoideum. Practically, also, both these folds and the vascular lining of the antrum may play an important part in the event of mastoid implication requiring operation, in reference to questions of local phlebotomy and subsequent drainage.

CHAPTER II

ASEPTIC TECHNIQUE

SURGICAL success to-day probably depends more generally upon the employment of strict aseptic and antiseptic methods than upon the skill of the operator. This can be said truly without for a moment underestimating the value of that rare faculty sometimes called surgical sense, of that clear judgment which seems to guide its possessor with the rapidity of intuition in determining when to operate and when to abstain, or the importance of that thorough knowledge of surgical measures which enables one to select promptly the particular operation best adapted to any given condition. Nor does it mean that the unskilled operator will, simply by the aid of antiseptic precautions, achieve better results than his skilled brother who makes use of the same assistance. Given the choice between two operators, however, the one possessing possibly a lesser degree of skill but a higher regard for absolute surgical cleanliness than the other, and it may safely be said that the clean man will prove to be the safer surgeon.

An important lesson is contained in this for the surgeon practicing in a special and limited field. However accurate and complete his knowledge of the minute anatomy of the organ or region with which he has to deal,

however skillful he may be in the manipulation of instruments especially devised for his art, if he ignores the simple rules of aseptic preparation, or neglects the equally plain antiseptic precautions, he will occasionally have cause to regret his lack of care. It has long been a standing reproach to the special surgeon that his technique fell short of that commonly employed by the general surgeon; and while the aspersion has not been entirely merited and the degree of his shortcoming has often been unfairly exaggerated, it has resulted in a retardation of clinical progress along special surgical lines.

The otologist, with more intimate knowledge of anatomical relations and of the physiological importance of the various parts of the organ of hearing, together with a more comprehensive understanding of the modes of transmission of disease from the ear to neighboring structures, than is possessed by the general surgeon, has a decided advantage, and should intelligently equip himself to perform operations for the relief of conditions which have their origin in aural affections. Hence he should be able not only to work within the limited confines of the middle ear or to enter the broader field of mastoid surgery, but he should be competently prepared to enter the cerebral cavity in search of a brain abscess or other lesion resulting from otitic disease.

The three cardinal principles requisite to success in this work are: (1) A preliminary general medical and surgical training, supplemented by a broad knowledge of otology; (2) the skill which can be acquired only by familiarity with delicate manipulation, sustained by thorough painstaking practice; and (3) faithful, conscientious adherence to the laws of aseptic surgery.

Aseptic surgery means the production and maintenance of an operation wound free from infection by pathogenic germs. This requires disinfection of the field of operation, and then continuance of the aseptic condition during subsequent treatment—an end which can ordinarily, with due care and precaution, be attained. That absolute disinfection of the skin is a condition approaching the impossible was shown long ago, when Prof. W. H. Welch [1] demonstrated the normal presence of the Staphylococcus epidermidis albus in the skin and the hair follicles at such depth as to escape the effect of chemical disinfection of the superficial layers. Others have proven since that the skin is the common habitat of several different organisms. Under ordinary circumstances these are not pathogenic, however, and their presence in a wound in small numbers does not necessarily interfere with healing. Nevertheless, efforts at complete sterilization should not be relaxed, and until thoroughly cleansed, the skin of both patient and surgeon must be considered to be infectious. While many other factors besides the mere presence of pathogenic organisms enter into a proper consideration of the production of sepsis, we need only consider here the usual channels by which germs gain an entrance to wounds, and the best methods adapted to prevent such access. This calls for attention to the surgical cleanliness of the part to be treated, of the surgeon's hands and those of his assistants, of the instruments, surgical dressings, and all objects likely to come in contact with or in close proximity to the site of operation.

[1] "Conditions Underlying the Infection of Wounds." *Trans. Cong. Amer. Phys. and Surgs.*, vol. ii.

Antisepsis.—This term includes all the measures which may be employed to destroy or render inert any pathogenic organisms or their poisonous products. The agent most generally used, and which possesses the widest range of applicability, is heat. Chemical disinfectants have but a limited degree of usefulness because of their corrosive action. Disinfecting gases, such as formaldehyde, used with proper care and under suitable circumstances, possess certain advantages over all other means; especially is this true of the sterilization of instruments, which are easily damaged by corrosive chemicals or by extreme heat in whatever form applied. It should not be forgotten either that mechanical cleanliness is a most important, if indeed it is not the most important, part of any method of disinfection, and that the free use of the scrub brush with alkaline soap and hot water on any object should precede the employment of other means of sterilization.

The medicinal and surgical measures to be taken to oppose sepsis when established in the individual are considered in another chapter.

STERILIZATION OF INSTRUMENTS

Heat exerts a decidedly injurious effect upon all sharp-edged instruments, and this fact has led to numerous efforts to establish some more satisfactory means of sterilizing them, some means which, while certain to destroy all septic organisms, would not at the same time destroy the cutting edge. Immersion of instruments in alcohol has been widely used as a substitute for exposure to heat, but experimental evidence proves it to be inefficient. Infected instruments have been submerged in absolute alcohol for

twenty minutes, and then cultures taken from the pre-
viously infected parts showed a growth of the organism
in eighty-six per cent of the cases. In the present day no
agent should be relied upon as a sterilizer if it fails in
any way to meet the most rigid and severe tests of the
bacteriological laboratory. It is self-evident that the best
working principles of disinfection require the absolutely
certain destruction of all pathogenic organisms, in the
shortest possible time, at the least expense, and with a
minimum of injury to the object disinfected. But one
practical method for the treatment of instruments, aside
from that of boiling, which is preëminently certain in its
effect, has been suggested as meeting all these require-
ments, i. e., sterilization with formaldehyde.[1] This gas is
not only equally as effective as heat, but possesses certain
advantages over the latter. Repeated sterilization by this
method leaves the instruments as bright and untarnished
as when new. The blade of a knife, for instance, suffers
no deleterious change; the degree of sharpness is the same
after as before disinfection. The expense is trivial, the
labor involved is almost nothing, and the apparatus re-
quires no watching; once started, it may be left unat-
tended, with the certainty that the instruments will be
sterile in ten minutes, and with the further assurance that
no harm will befall the instruments even though they be
left in the gas for days.

The formalin sterilizer may be made of any material
which permits of forming and maintaining an air-tight
chamber, and of such size and shape as best suits the
needs of the surgeon. For the use of the aurist an appa-

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[1] *Bulletin of the Johns Hopkins Hospital,* December, 1897.

ratus made in accordance with the following description serves very well. It consists of a copper box 7 × 12 × 12 inches, with an air space of a little more than 1,000 cubic inches. The shelves are made of heavy wide-meshed wire gauze, the upper shelf extending entirely across the chamber, while the two lower shelves are only 8 inches long, extending from the right side to an upright standard 4 inches from the left wall, thus leaving a space 4 inches wide by 8 inches high which is reserved for the alcohol lamp used in vaporizing the pastils. The lamp should be lighted and placed in its compartment first, and the instruments then laid on the shelves, or arranged on an instrument rack or in a suitable tray, and the whole placed in the box. Lastly, the paraform tablet (5-grain size is sufficient) should be crushed between the fingers and dropped into the cup over the flame, and the door of the chamber tightly closed. The early lighting of the lamp heats the cup thoroughly, and when the paraform is introduced vaporization begins at once. In ten minutes the door may be opened and the instruments removed sterile. The flame will have expired for want of oxygen in less than ten minutes, but it burns long enough to secure complete vaporization of the pastil—all that is required of it, the trifling amount of heat thrown out playing absolutely no part in the process of sterilization.

Naturally the question arises whether the amount of gas adhering to the instruments may not be injurious to the tissues. There is no visible sublimate on the blade, and while it is theoretically possible that such a deposit is present, it has been shown by experimental tests to be inert.

The use of dry heat for the sterilization of instruments is impracticable, because of the very high tempera-

ture required for effectiveness, and because hot air, like steam, is injurious to instruments.

Live steam is thoroughly destructive of all micro-organisms, and a variety of sterilizers rendering its use practicable for almost all disinfecting purposes, and for all times and places, are now obtainable.

The method most commonly employed for the sterilization of instruments, however, is the process of boiling in soda solution. Instruments should be boiled for at least five minutes, a one-per-cent solution of carbonate of soda being used in preference to plain water, since the alkali tends to prevent rusting, and hastens the destruction of bacteria by its solvent action upon their capsules.

After removal from the sterilizer the instruments should be placed in a sterile tray and kept dry, or the rack upon which they rested in the sterilizer lifted out with them and the whole carried to the instrument table. Some operators prefer to have their instruments immersed in an aseptic or antiseptic solution during the operation period, and for this purpose nothing is better than simple sterile water, sterile soda solution, or a weak solution of carbolic acid. It goes without saying that whatever trays or dishes may be used in this way must have been first thoroughly cleansed and disinfected. They may be of glass, porcelain-lined or agate ware, the first making the best appearance but the latter being the most serviceable. In the transfer of instruments from the sterilizer to the operator, care must be taken to avoid any chance of their becoming infected. When the instruments to be boiled have been wrapped in a cloth or a towel, the bundle should be bound with a strip of tape or gauze long enough to leave projecting from the sterilizer an end by which it

may be seized and carried to the instrument table without touching the bundle, the unwrapping of the instruments and their disposition being left to the surgeon or his sterilely prepared assistant. The nurse or assistant intrusted with their preparation should, after seeing to the proper arrangement of the receiving vessels, cleanse and disinfect the hands as carefully as though preparing to perform the operation, before attempting to remove the instruments. The person who is to have charge of the instruments during the operation should be equally clean, and should be constantly watchful, before and during the operation, of every instrument, so that the moment one is observed to come in contact with any object not known to be sterile (other than the operation wound) it may be at once returned to the sterilizer and disinfected before being again placed at the service of the surgeon. After the operation, every instrument used should be carefully scrubbed in hot water, to remove all particles of dried blood or infectious secretions, and thoroughly dried before being put away. If the operation has been one of a markedly septic type, so that the instruments are likely to have become dangerously contaminated, they should, in addition to this mechanical cleansing, be again sterilized.

PREPARATION OF DRESSINGS

Steam sterilization is the only thing to be recommended here for general work. Where only a small quantity of loosely rolled material is to be sterilized, the formalin apparatus may be employed; but since the penetrating power of this gas is not yet definitely and absolutely determined, it should not be trusted where large or dense packages are to be rendered sterile. With the use of

steam, what is known as the fractional method should be followed; i. e., after subjection to steam for one hour the process should be stopped for twenty-four hours, and then repeated for half an hour on each of the next two days.

A supply sufficient to last several days, or even weeks, may be sterilized at one time and kept in stock. In this event the material should be divided into a number of small packages, so that just so much, or little, as may be desired at one time may be taken without fear of contaminating the whole; not more than two or three towels wrapped together; cotton in small portions; from two to a dozen gauze sponges or pads of different sizes; and single bandages; all of which may be wrapped in linen or gauze and sterilized, and then later inclosed in a wrapping of waxed paper, if it is intended to preserve them sterile for any length of time. All can be kept in suitable glass jars, and the nurse, when producing a package, unpins the cover, turns back the folded flaps, and, without touching the contents, holds it for the surgeon to take from it what is needed.

Gauze is not only the best form of dressing for most major surgical work, but makes the best possible sponges for use during operation. A moderately fine-meshed cheese cloth of soft texture, about No. 6, is best. For dressing pads it can be cut in strips measuring 5×32 inches, and folded into rectangular blocks of $2\frac{1}{2} \times 4$ inches. A convenient size for sponges is $1\frac{1}{2} \times 1\frac{1}{2}$ inches, and these can be made by cutting strips 6×6, folding twice and then tucking in the ends.

Iodoform Gauze.—A satisfactory working formula for the preparation of this gauze, sufficient for a small hos-

pital, is as follows: Take six yards of gauze, and after allowing it to soak in a 1 : 1,000 solution of bichloride for twenty-four hours, wring it out dry, with sterile hands, and place it for twenty-four hours more in a solution of carbolic acid 1 : 500; then make an emulsion of iodoform, glycerine, and alcohol, each three ounces, and carbolic acid one dram, and rub into the gauze thoroughly, an operation that usually requires about two hours of hard labor. The hands must be sterilized as carefully as for an operation before beginning this work.

BANDAGES.—The common roller bandage can be satisfactorily employed in the majority of cases, and may be made of gauze, bleached cheese cloth, muslin, or linen, cut in strips 4 to 8 cm. wide, and rolled.

COLLODION DRESSING.—When a granulating mastoid is nearly healed, with practically no secretion exuding, and it is desirable to do away with cumbersome and unsightly bandages, a small neat dressing for protection is attained by the use of collodion. The skin for some distance from the wound should be wiped with gauze soaked in alcohol, to remove any of the glandular fatty secretions, a bit of gauze laid in or over the wound, this covered with a thin layer of sterile absorbent cotton, and the whole fastened down by collodion brushed over it, or by laying on as a last covering a thin layer of gauze which has been soaking in collodion. It adheres easily to the clean skin, dries rapidly, and forms a firm protection.

PREPARATION OF LIGATURES AND SUTURES

The ligature is not much used in aural work, since such hemorrhage as is likely to occur may usually be easily controlled by simple pressure for a few moments,

by temporary clamping with artery forceps, or by torsion. In mastoid surgery, however, ligatures should always be at hand. The posterior auricular artery, when encountered, sometimes requires tying, and it may be unexpectedly necessary to invade the neck and ligate the internal jugular vein. In the choice of material catgut holds first place, so far as its absorbability into the tissues is concerned. Surgeon's silk is not absorbed, but it readily becomes encysted in a clean wound, and possesses the advantage of being more easily prepared and maintained in an aseptic condition than catgut. It can be obtained of any desired size, and may be sterilized at the same time as the instruments, just prior to the operation in which it is to be used, but a somewhat longer period of boiling —say ten minutes—is essential to insure complete sterilization. The long, tedious, and uncertain methods employed to sterilize absorbable animal ligatures have always militated against the use of these otherwise valuable materials in surgery. It is possible now to secure catgut, silk, silkworm gut, and kangaroo tendon, of varying sizes, properly prepared by reliable manufacturers, and wrapped in aseptic, convenient packages. If preferable to have it prepared under personal supervision, as may be the case in hospital work, the method known as Hofmeister's is one of the best.

1. The catgut is wound on a glass plate with slightly projecting edges, so that the gut is free from the sides of the plate and exposed to the circulation of the boiling water. The ends of the gut are fastened through holes in the plate.

2. Immersion for from twelve to twenty-four hours in an aqueous solution of formalin, two to four per cent.

3. Immersion in warm water, to free the gut from the formalin.

4. Boiling in water from ten to thirty minutes, to destroy microbes.

5. Hardening and preservation in absolute alcohol containing five per cent of glycerine and one per cent of corrosive sublimate.

In this method the ordinary commercial catgut is subjected to the action of formalin without any previous preparatory treatment, and experiments have shown that a chemical change takes place which renders the gut of greater tensile strength and permits of its being boiled afterwards without injury. When wound in suitable lengths on glass bobbins, these may be kept sterile for a long time in a common ignition tube.

Silk is most widely used as a suture material, and for convenience may be wound on glass bobbins before boiling. It may be cut in lengths to suit—12 to 30 inches— and needles threaded on each when winding the spool.

The silver-wire subcutaneous suture with silver-foil dressing is receiving a deserved indorsement from general surgeons, and has been found very satisfactory in mastoid surgery. Wherever it is desirable to aim at union by first intention it is especially valuable. Not only is the sterilization of this suture absolutely sure (it can be boiled with the instruments), but, if used subcutaneously, it avoids the main source of suture infection—i. e., passage through the epidermis—and, in addition, it exerts an antiseptic effect in the tissues. At the proper time for removal, too, it is easily and quickly withdrawn without any discomfort to the patient. The silver foil for top dressing should be cut in strips of 2×4 inches, and kept

in packages of ten sheets, with tissue paper between. These packages are to be sterilized along with the other dressings.

PREPARATION OF OPERATOR AND ASSISTANTS

The point requiring most care in the preparation for any operation is the personal cleanliness of the surgeon and of the patient. It is a comparatively simple matter now to insure the sterility of instruments and dressings, but persons cannot be treated to such heroic measures as boiling or steaming. Experimental work performed by the most eminent investigators has shown that the skin is the normal habitat of more than one variety of pyogenic organism, and that perfect sterilization is not possible, or at least not practicable. Surface sterilization is the most that can be hoped for from the present methods, but that can be done so satisfactorily as to reduce the dangers of wound infection to a very small point—so small, in fact, that if a clean wound becomes infected the surgeon cannot claim exemption from blame on this score.

Of all the methods suggested for preparing the hands the following seems to be the one most worthy of recommendation. It is based upon scientific principles, and its satisfactory working has been practically demonstrated by competent observers.

1. The hands and forearms are vigorously scrubbed for ten minutes with a brush, using common brown kitchen soap or green soap and hot water. Particular attention must be given to scrubbing the surfaces between the fingers, and to the nails, the free ends of which must not be more than a millimeter in length. The most vigorous efforts in washing must be devoted to the spaces beneath

and about the nails. The water should be as warm as can
be comfortably borne, and either constantly changed with
fresh water running in, or poured out and changed com-
pletely four or five times.

2. The hands, thus mechanically cleaned and softened,
are next immersed in a hot saturated solution of perman-
ganate of potassium until stained a deep mahogany color.

3. They are then immersed at once in a saturated so-
lution of oxalic acid, which decolorizes and completely
sterilizes them. The oxalic-acid solution should be as
warm as can conveniently be borne.

4. The oxalic acid may be removed by rinsing the
hands in warm water, but it is better for this purpose to
keep a dish of sterilized limewater on hand, which at once
precipitates the oxalate of lime.

5. Lastly, the hands should be dipped in a solution
of bichloride of mercury (1 : 500), and, by aid of a gauze
sponge, the forearms bathed with the same for several
minutes.

6. In addition to the above preparations many opera-
tors now habitually use rubber gloves.

A second method, which is perhaps equally good, and
which has certainly grown rapidly in favor during the
past few years, consists in following the directions given
in paragraph No. 1 as to the preliminary cleansing and
scrubbing and then soaking the hands in alcohol for sev-
eral minutes; dispensing entirely with the permanganate
and oxalic-acid solutions and substituting the alcohol treat-
ment. The effectiveness of alcohol as an agent for the
surface sterilization of the skin is unquestioned. It has
been shown experimentally that the quickest disinfection
that can be relied upon is scrubbing the hands for five

5

minutes in alcohol. Surface sterilization may be consid-
ered sufficient when gloves are to be worn, but when pre-
paring for a prolonged operation without gloves a more
thorough effort to secure sterility of the deeper layers of
the skin is desirable, and is afforded by the permanganate
and oxalic-acid solutions.

OPERATING SUIT.—A complete suit comprises a gown,
a cap or sterile towel for the head, and gloves. The gown
should, preferably, be made of linen or crash, plain in
front, and fastened on the back with buttons or short
pieces of tape. It should fit closely at the neck, above the
collar, loosely elsewhere, and have sleeves fastening by
tape at the elbow or wrist. These gowns can be sterilized
and kept in stock in the same manner as sterile towels.
Caps made of the same material should be provided for,
and worn by, the surgeon to prevent possible contamina-
tion of the wound by falling hair or dandruff. The em-
ployment of sterile thin rubber gloves is certainly to be
commended, and while the necessity for and the advan-
tages of it have not been so clearly proven, the tendency
to complete the operating costume by the wearing of a
gauze face mask, to reduce the possibility of infection by
spray from the nose and mouth, is not amiss.

NAIL BRUSHES.—In hospital, as in private office work,
it is best that every person should have his own individual
brushes. It is then known under just what conditions
they have been previously used, and the possibility or
probability of their being infected. The bristles must be
stiff, to permit of efficient scrubbing, and after use in a
septic case the brush should be boiled before being placed
in its ordinary receptacle. After each use the soapsuds
should be thoroughly rinsed out of the bristles, and be-

tween times of use the brush should be kept in a covered jar containing a 1:500 solution of mercuric chloride. An equally good plan is to have the brushes wrapped separately and sterilized with the towels and dressings, one to be unwrapped for use as needed.

THE HOSPITAL OPERATING ROOM

Too much care cannot be expended upon the construction or remodeling of this room, to make it meet the requirements of modern surgery. Instead of setting aside for this purpose any room that could not be conveniently used otherwise, it should command a choice location and a carefully selected though simple equipment. The ideal room is constructed with the following points in mind: In the first place, an abundance of light must be obtainable at all hours. A large window space occupying the greater portion of one side of the room, preferably the north, for the softer, steadier light, supplemented if possible by a skylight, is most desirable. An electric chandelier, with reflectors to throw a bright illumination on the table, will serve best for night work. A portable electric lamp is also a desirable addition to the equipment.

The walls and floor must permit of easy and thorough cleansing. There should be no corners to collect dust; the walls should curve into one another without intervening cracks or rectangular joints, and the ceiling and floor should meet the walls with similar curves. Both walls and ceiling should be of smooth finish, and painted with a smooth hard surface that will allow of frequent washings with antiseptics. The best material for flooring is marble tiling.

The plumbing should be of the open kind, every part exposed, not set close to the wall, and should provide for an abundant supply of hot and cold water. The number of wash basins required depends upon the amount of work to be done; the flow of water should be controlled preferably by foot taps. Above the row of basins there should be a shelf to hold the row of jars containing the nail brushes or hand scrubs. There should be a jar of green soap at hand, and a series of basins containing sterilizing solutions.

At one end of the room there should be a stand with the instrument sterilizer, and near by an instrument closet. A vessel containing calcium chloride placed in this closet tends to keep the atmosphere free from moisture and to prevent rusting of the contents. Several small tables, for holding instruments, pans, dressings, and articles used by the anæsthetizer, complete the equipment.

OPERATING ROOM IN PATIENT'S HOME

The tendency at present is to transfer all operative work, whether minor or major surgery, to the hospital, where the most improved facilities and the aid of specially trained assistants increase the chances of success. In many instances, owing to prejudice against such institutions or to the impossibility of moving the sufferer, even the most difficult operations must still be performed in the patient's home. A fairly well-lighted room can generally be found in any house, and a common kitchen table, covered with a folded blanket and clean sheet, serves very well as an operating table. In an ordinary dwelling house or a farmhouse the kitchen is usually the cleanest room. All hangings, carpets, and rugs should have been

previously removed, and the walls cleaned and floors scrubbed carefully and thoroughly. The object in view is to get rid of as much dust as possible. A quantity of hot water should be ready for use at any moment. Practically everything else can be supplied from the surgeon's operating kit.

PREPARATION OF PATIENT

This is next only in importance to the preparation of the surgeon and his appliances. It consists, broadly, not only in the effort to disinfect the field of operation, but in all those measures which tend to insure the success of the operation and promote the safety and comfort of the patient. Supposing that there is no imperative demand for immediate surgical intervention, and that time is permitted for the proper arrangements, the patient's general condition should first be considered. A physical examination of the heart and lungs and chemical investigation of the urine should be made, to ascertain whether any special danger is to be apprehended from the production of general anæsthesia. Whenever possible, it is a good plan to make use of the early morning hours for the performance of surgical operations. At such time the operator and his assistants are usually at their best, refreshed by a night's rest, and with every sense on the alert. The patient, too, as a rule, has benefited by this rest period, and enters the operating room in a calmer mood than when harassed by several waking hours of fearful anticipation. If the surgeon himself can find the opportunity to speak a kindly word to the patient, sounding a note of promise or encouragement, just prior to the commencement of the anæsthesia, it often helps greatly to produce

a tranquil state of mind, and to inspire confidence in the assistant who is to conduct the sufferer into this temporary sleep. With thorough confidence in those about him, and a hopeful feeling as to the outcome, a patient is less inclined to struggle against the disagreeable sensations induced by the anæsthetic, and to require a less amount for the production of insensibility.

When time allows, the operation site should be prepared the night before, or at least some hours before, the time set for operating. Perfect disinfection of the skin is hardly possible with present methods. The best that can be done—and it is fairly satisfactory—is to follow the general laws here given, modifying them only as necessary for adaptation to certain·parts. Where the skin is to be dealt with, as in operations about the auricle or mastoid region, the surface should first be shaved to remove all hairs, and then carefully scrubbed with hand brush and alkaline soap to remove gross dirt and soften the tissue. The soap, epithelial cells, etc., should be removed by washing with sterile water, and the cleansed surface then thoroughly scrubbed with pledgets of gauze soaked in alcohol, and the disinfected area then covered by a sterile dressing, and bandage applied to hold it in place until the surgeon desires it uncovered.

Where emergency demands immediate operation the same process of cleansing may be utilized after the introduction of anæsthesia. In cleansing the external auditory canal, cotton-tipped probes or cotton gauze sponges may be used for the scrubbing with soap and water and for the thorough application of alcohol. In the effort to disinfect a mucous surface we are limited to the employment of drops, sprays, or irrigation with antiseptics. For this

purpose alcohol or formalin (ʒi to Oj of water) have proved to be most useful.

Before beginning an operation, the surgeon, or some of his assistants, should see that the exposed field is fully protected from any possible contamination from its surroundings. A sterile rubber cap should be placed on the head to keep the hair back, and sterile towels employed freely to cover the neck, shoulders, and body of the patient, and the operating table, so that the operator cannot touch anything which might be surgically unclean.

ANÆSTHESIA AND ANÆSTHETICS

A very large proportion of the operations upon the auricle or within the tympanum may be performed under local anæsthesia, but nearly all mastoid or cranial surgery, and many intratympanic manipulations, will require narcosis. The choice of an anæsthetic and its safe administration are matters of great importance to the aurist, because not infrequently the only danger attending an aural operation is the small yet positive risk of fatal anæsthetization. Perfect asepsis, the invention of especially well-adapted instruments, and the growth of operative skill, have made much of aural surgery comparatively simple; the hazard of unnatural sleep remains a factor to be reckoned with in every instance. It thus becomes apparent that in very many aural operations the anæsthetist occupies a more responsible position than the surgeon, and that the latter should, whenever possible, avail himself of the services of a skilled anæsthetizer. It is scarcely too much, in the present advanced age, to say that an untrained person should never be permitted to administer an anæsthetic, and it is earnestly to be hoped that in the

near future a supply of young physicians, thoroughly equipped as specialists in the handling of this class of dangerous drugs, will appear in every large community.

The recognized general anæsthetics can have but a small mortality when given properly to healthy persons. It is only when such vital organs as the heart, lungs, or kidneys are pathologically affected, or the blood is impoverished in oxygen, that inherent danger attaches to the anæsthetic, or that it becomes necessary to weigh carefully the relative virtues of the several narcotics.

Ether would seem to be safer than chloroform when any lesion of the heart exists, yet it is only in myocarditis, or valvular disease with inefficient compensation, that special apprehension need be felt concerning the direct cardiac effect of either, and no condition of the heart is an absolute contraindication to the employment of anæsthetics. Ether is contraindicated in all cases of impaired respiration, because of its irritating influence upon the respiratory mucous membrane. Chloroform is preferable for very fat individuals, persons with short necks, and those addicted to alcoholic habits. When the kidneys are diseased the greatest care must attend the administration of either chloroform or ether; the latter should be preferred, unless distinctly contraindicated for other reasons, and the smallest quantity compatible with the production and maintenance of narcosis used.

The majority of surgeons consider ether a safer anæsthetic than chloroform, excepting under the special indications noted, but the partisanship of the advocates of each drug is rapidly disappearing. Undoubtedly the risks pertaining to etherization have in the past been underestimated, even if the fatalities of chloroform have not

been exaggerated.   A liberal consideration of all the elements bearing upon a choice between the two, however, shows sufficient reason for preferring ether to chloroform as the anæsthetic in general.

For operations which require complete narcosis, but in which this state needs to be maintained for a short time only, such general anæsthetics as nitrous-oxide gas, ethyl chloride, and ethyl bromide have recently met with deservedly high favor.   It has long been accepted as a fact that nitrous oxide is the safest of all anæsthetizing drugs, and from the statistics so far published it now appears that ethyl chloride and bromide, in the order named, are the next least dangerous compounds.   It is essential, in using either of the ethyl compounds, that absolute chemical purity shall be required, and it must not be forgotten that even the pure drug, especially the bromide, easily undergoes chemical changes which render it exceedingly dangerous.   Either preparation can be obtained from reliable manufacturers in flasks containing a sufficient quantity for one administration.   The contents of the bottle should be poured into the cone and the latter applied so as to exclude air.   About two minutes is required to secure the full effect, and profound anæsthesia lasts from two to four minutes.   Among the advantages pertaining to these preparations are the comfort with which the patient goes to sleep, the brief duration of narcosis, the rapidity with which complete consciousness and normal muscle action are restored, and the absence of subsequent nausea and discomfort.   A fresh flask must be used for each patient, and the cotton or cloth lining the cone should not be employed a second time.

Nitrous oxide may be given alone, or in combination

with air, oxygen, or either of the anæsthetics previously mentioned. Until a comparatively recent time it was supposed to be of service as an anæsthetic for the performance of minor operations only, but in some hospitals it is now employed for major surgery requiring anæsthesia of half an hour or longer. In operations likely to be of a prolonged character, its main advantages lie in its use as a preliminary to the employment of ether or chloroform. It materially lessens the discomfort of the first stage of anæsthesia, shortens the period necessary to produce complete narcosis, and distinctly reduces the after effects, especially nausea. The inhaler devised by Thomas L. Bennett,[1] of New York, has proved fairly satisfactory, and solves the problem of definitely controlling the supply of nitrous-oxide gas, ether vapor, and air. By its use it is possible to completely anæsthetize a patient in from two to five minutes by the gas, and then to cut off the gas supply and turn on the ether for a continuance of narcosis, without removing the inhaler. The weight of the instrument is such that it becomes tiresome for the anæsthetizer to hold it long, and therefore it is frequently used only until anæsthesia is perfect, when the ordinary ether cone is substituted.

Quite recently [2] Gwathmey has devised a new form of vapor inhaler, and his method of administering oxygen with chloroform or ether gives promise of additional safety and comfort.

To secure the greatest degree of safety in the employment of anæsthetics certain precautionary measures should always be observed. All food should be withheld for at

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[1] *Med. Record*, New York, March 24, 1900, p. 524.
[2] *Med. Record*, New York, October 14, 1905, p. 609.

least five hours prior to the administration of an anæsthetic. This, with the aid of a cathartic at bedtime, and, if necessary, an enema in the morning, empties the bowels and puts the gastrointestinal tract at rest.

In preparation of the patient for operation all unnecessary clothing should be dispensed with, and special care taken to see that there are no constricting bands around the chest or abdomen. Artificial teeth or other foreign bodies should be removed from the mouth. A recumbent position, with the head slightly lower than the body, is most favorable, and care should be taken at all times to keep the pharynx and mouth free from secretions, and to facilitate the expulsion of vomited matter. Excessive force should never be employed to control a patient's struggles; a little reasoning, more gentleness, and a slower administration of the suffocating vapor will be much more effective and decidedly less dangerous. A preliminary hypodermic of morphia and atropia, administered from thirty to sixty minutes prior to the anæsthetic, or a moderate dose of whisky or brandy taken by the mouth, has been strongly recommended by some high authorities as tending to stimulate the heart, allay the patient's nervousness, and diminish the amount of mucous secretions in the respiratory tract. Certainly it would seem to be a harmless procedure, and, while not necessary as a routine, one which is to be commended in many cases. By covering the patient carefully with blankets and watching him throughout the operation to avoid exposure and chilliness, something is gained toward preventing postanæsthetic lung complications.

The open and continuous drop method of supplying chloroform to the mask is far better than pouring it on

at intervals, and a sufficient supply of air must be constantly provided. Just as nitrous-oxide gas induces a more satisfactory preliminary anæsthesia, so it may sometimes add much to the patient's comfort to begin narcosis with chloroform and substitute ether after the first trying period is passed. In any event, it is advisable to limit the amount of an anæsthetic to the smallest quantity necessary to induce the desired state of painlessness. Oftentimes it is possible to sustain this condition by interrupted narcosis. In mastoid work, for instance, curettement of the bone is not very painful, and it is unnecessary to keep up a constant, profound narcosis.

An emergency outfit, consisting of a hypodermic syringe, an infusion apparatus, and a variety of cardiac stimulants for subcutaneous use, should always be in readiness. Weakened heart action or symptoms of impending asphyxiation demand prompt action. Reliance has generally been placed on stimulation by strychnia, brandy, digitalin, or nitroglycerin. Recent studies on the nature of shock and the action of anæsthetic poisoning indicate that infusions of warm normal salt solution are more efficacious than the administration of other cardiac stimulants.

CHAPTER III

DISEASES OF THE AURICLE AND EXTERNAL AUDITORY CANAL

ABNORMALITIES OF POSITION AND FORMATION

MALPOSITION and malformation of the auricle are very common conditions, if all departures, of whatever degree, from a normal standard for position and form be considered. Preliminary to a consideration of the abnormalities, it would be well to determine what constitutes a standard normal ear, for it is a noteworthy fact that, although anatomical irregularities of the auricle have formed the basis of a great many papers, and a great deal of consideration has been given to the question of the relation of these markings to the stigma of degeneration, there has been no general concurrence upon a standard. For comparative purposes, then, the following description might be accepted as that of a normal ear: It should be, approximately, twice as long as it is broad, and in its relation of attachment to the head should form an angle of not less than fifteen degrees nor more than thirty degrees therewith. It should have a gracefully curved outline, being nowhere pointed nor irregular, and have a well-defined helix, separated from the antihelix by a distinct scaphoid fossa extending down nearly to the level of the antitragus. The root of the helix should be lost in the concha before

reaching the antihelix, which should not be unduly prominent, and should have a well-marked bifurcation at its superior extremity. The lobule ought to be shapely, not adherent to the cheek along its anterior border, nor yet too pendulous, and free from grooves extending from the scaphoid fossa.

Moderate degrees of variation from this standard, as regards both position and form, are common, and will be noted more frequently in the male than in the female sex. This is doubtless due to the rougher and more exposed life of boys and men, and to the character and mode of wearing their headdress. Gross alterations of form, such as constitute generally noticeable malformations, cannot be said to be very common, and yet they are not infrequently met with. They also vary greatly in character, from an irregularity of some one portion of the auricle to its entire absence, or to the existence of superfluous appendages.

MALPOSITION.—Very close-set auricles, those which show an auriculo-temporal angle of less than fifteen degrees, are rare, and possibly never call for the surgeon's attention. Flaring ears, however, especially when the angle is greater than sixty degrees, are apt to be unsightly, and, for cosmetic purposes, demand the operation of replication. When such deformity is noticed in childhood a partial or complete correction may be accomplished by the patient and prolonged employment of some device for pressing the auricles close to the head. Thus, a cap that can be drawn down over the ears may be worn during the day, instead of the regulation headgear of the period, and a special close-fitting nightcap, or bandage, be applied at night. In adults, when the cartilage has become more

firmly developed, or when the flaring out of the auricle is excessive, surgical measures must be the natural resort.

The best methods yet devised for operating upon these cases, and those which have produced the most satisfactory results, are the operation which has been suggested by Keen,[1] and the removal of an elliptical surface of skin from the angle of junction of the auricle with the mastoid and the stitching of the cut edges together. Care must be taken to secure bilateral symmetry when both ears are operated upon, and this is facilitated by first cutting a paper pattern of the piece of skin to be removed and using this to mark out the operation area. Keen's operation consists in the removal of an elliptical piece of skin and a wedge-shaped piece of cartilage, and in retracting the auricle by closing this wound with sutures. A careful aseptic technique should be observed preliminary to and during operation. Not only the entire surface of the auricle, anteriorly as well as posteriorly, but the neighboring regions on the face, neck, and scalp should be scrubbed thoroughly with soap and water, and washed with alcohol or ether, such hair as might encroach upon the field having previously been shaved off. The head and shoulders must be covered with sterile towels, and only sterile hands or instruments permitted to come into contact with the exposed clean area. Having determined the amount of resection necessary to bring about the desired effect, a vertical ellipse of skin is removed from the posterior surface of the auricle, starting above at the beginning of the convexity of the helix and extending down to the commencement of the lobule. This exposes a broad expanse of

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[1] *Annals of Surgery*, 1890, vol. xi, p. 49.

cartilage, from which a triangular section, about two thirds the width and the entire length of the skin wound, is to be cut. Great care must be exercised in sloping the edges of the incision in the cartilage in order that they may meet at the apex of the wedge, just at the anterior surface of the cartilage, without wounding the skin. A subcutaneous silver-wire suture affords the best means of perfectly closing the wound and promoting primary union. Such closure avoids further injury of the cartilage, suture of which does not seem to be requisite to success, and eliminates the possibility of infection from stitch abscesses so common after interrupted sutures through the skin. Having closed the wound by drawing the wire suture taut, it should be covered with sterile silver foil, a small pad of plain gauze placed over this, and then the auricle pressed close to the head by a gauze pad over the anterior surface, held in position by a firm bandage. The dressings need not be changed for a week, at which time the wire suture can be easily withdrawn and a light collodion dressing applied over the wound. An elastic flannel bandage should be worn constantly for a time, and at night for several weeks. Some surgeons have relied on excision of a portion of the skin on the posterior surface of the auricle only, leaving the cartilage intact; but this method is open to the objection that the natural elasticity of the cartilage will tend to stretch the skin, and cause in time a recurrence of the deformity. Several years prior to Keen's publication Ely [1] had described a somewhat similar operation, but his results were not as good; he made his incisions directly through all the tissues of the auricle, and

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[1] *Archives of Otology,* New York, 1881, vol. x, p. 97.

in consequence thereof found it difficult to coapt the edges of the wound, and left an unsightly scar on the anterior surface.

MALFORMATIONS.—The human auricle exhibits a great variety of abnormalities in form, the origin of only a few of which can be explained. There may be a defect of any portion of the pinna due to an arrested development of that part either before or after birth, or, on the other hand, an excessive development of some of its divisions. In some instances there is total absence of the auricle, in others a rudimentary organ exists, and, again, a condition of polyotia is found. Whether the abnormal condition existing be one of microtia, macrotia, or polyotia, the deformity is probably due to an error in development of the first visceral cleft, the fissure in the embryonic head which marks the site of the future external ear.

Distortions of the helix, antihelix, tragus, lobule, or scaphoid fossa have little interest for the surgeon; he is but rarely called upon to correct them. The number of persons possessed of perfectly normal auricles is probably a small minority of the whole populace. The majority of people show some defect on one or both sides, but so do they present other physical shortcomings when measured by the ideal standard for the human body. Many writers have attempted to show some connection between abnormal formations of the pinna and mental degeneracy, and have attributed undue importance to these minor defects as the stigmata of degeneration. It is unquestionably true that they are found frequently as hereditary stigmata or degeneration signs accompanying mental weakness, and that a large percentage of the criminal classes, and neuropathic persons generally, bear such markings; but inas-

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much as the same defects are noted in at least half as
large a percentage of physically normal individuals, it
would seem only fair to conclude that anomalies of the
outer ear alone are not a standard for the diagnosis of
congenital mental defects, of however much value they
may be, for this purpose, when considered in connection
with other evidences of degeneracy.

Microtia.—This consists not, as the word implies, of
a diminutive ear, but, as the term is generally used, of an

undeveloped ear. There may
be a mere nodular or nipple-
like process on the cheek,
bearing no semblance what-
ever to a normal auricle, or
a larger, more or less curved
and twisted mass of skin,
connective tissue, and cartil-
age usurping the place of the
proper external ear (Fig.
11). Such a malformation
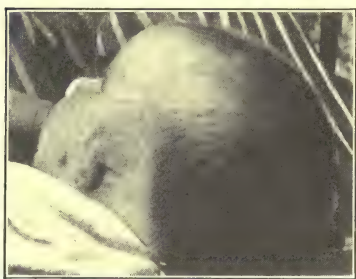
Fig. 11.—Microtia and Polyotia; baby
of six months, with small distorted
auricle, impervious canal, and a nip-
plelike process on the cheek.

of the outer portion is usually accompanied by abnormali-
ties of the middle ear. The meatus may be present, or
may be indicated by a slight depression only in the bone,
directed toward the tympanic cavity. Occasionally the
consistence of the mass is that of skin and soft tissue, but
usually firm compression will reveal the existence of a
hard, cartilaginous central axis (Fig. 12).

Polyotia and Preauricular Appendages.—In
addition to a normal or fairly well-formed auricle, we may
see a supernumerary growth, sometimes resembling an
attempt at auricle formation. The site of such superflu-
ous appendages is most frequently just in front of the

tragus, although they may appear anywhere in the neighborhood of the auricle.   In a few cases there have been observed, instead of a perfect ear, several rudimentary nodules on the cheek.

FIG. 12.—Distorted mass of cartilage occupying site of auricle.   Entire absence of external auditory canal.   Opening the mouth improved his hearing power.   Same aural defect on other side, and there was also coloboma of upper lid and choroid of left eye.

Either of these forms of maldevelopment may be unilateral or bilateral, more commonly the former, and there is no preference for either side of the head. Neither are they influenced by sex, for about an equal number have been reported for the two sexes.

Congenital aural fistula takes the form of a canal running parallel with the external auditory meatus, usually situated about one centimeter above the tragus and two or three millimeters in front of the anterior end of the helix. Its exact relationship to the development of the ear is undetermined. Whether it is an imperfectly closed portion of the first visceral cleft is uncertain. Generally it is not a true fistula, but a long, narrow cul de sac; occasionally a connection with the tympanum may be disclosed.

Only rarely do these fistulous tracts give rise to trouble. They are open to the possibilities of infection and abscess formation. Under normal conditions they exude a slight milky secretion. There is a decided tendency to heredi-

tary transmission, most frequently through the female
line, and they have been observed in all the women of one
family for four generations.

TREATMENT OF MALFORMATIONS.—The surgical treat-
ment of these conditions cannot be outlined with any
amount of detail. Each case must be a law unto itself.
It may be said, in general, that the useless appendages
may be removed without danger, and should be, if they
are causing marked deformity of the features. It is very
rarely wise to attack an imperforate meatus. Pathologi-
cal investigations have shown that a normal tympanum is
the exception in such cases, and clinical experience has
taught the almost hopeless nature of efforts to maintain
an open canal even when one has been successfully estab-
lished. An undeveloped auricle can be removed and an
artificial ear supplied, but, whenever possible, it is prob-
ably well to retain it as a base for the attachment of the
one made by art.

HEMATOMA AURIS—OTHEMATOMA (INSANE EAR)—PERICHON-DRITIS AURICULÆ—TRAUMATIC CYST OF THE AURICLE

Desirable as it may be, from the pathological stand-
point, to consider these affections separately, the indis-
criminate use of the terms and the confusing of their
distinctive clinical pictures, in many of the recorded
cases, combine to render it advisable that they be treated
conjointly.

Nothing definite or satisfactory is known about the
pathology of either of these conditions. In hematoma,
the effusion consists of pure blood or bloody serum. In
perichondritis, the contents of the swelling are of an in-
flammatory character—a cloudy serum, at first a few leu-

cocytes, and later numerous pus cells. The cysts contain a clear serous fluid. In all cases the effusion is found between the cartilage and perichondrium. After removal of the fluid, whether by absorption or evacuation, there is a tendency to the formation of new connective tissue, with thickening and distortion of the cartilage.

HEMATOMA AURIS, as its name implies, is an auricular tumor which contains effused blood. The older writers believed that this condition was to be found only among insane persons, and that some indefinite connection existed between the form and stage of the mental disturbance and the appearance of the tumor. It is now quite certain that hematoma occurs just as frequently among the sane as the insane, and that its origin has more to do with the occupation and habits of the individual than with his state of mind. Thus acrobats, boxers, athletes, porters, or others whose ears are subjected to frequent, even though slight, traumatisms, are not uncommonly the subjects of such tumors. A single violent blow on the auricle seldom produces a blood tumor; they seem to result rather from oft-repeated injuries which are capable of causing such changes in structure as predispose to hemorrhage. Just so, in the insane, these tumors are noted in that class of cases recognized as chronic dementia, or among the general paralytics who have reached the maniacal stage—a class of patients that is always restless, picking and pulling at their auricles, and rolling the head over the pillow when in bed, and subject to numerous small injuries. The appearance of the tumor may follow close on some definite infliction of a trauma, but generally the history of preceding irritation of a predisposing character can be obtained.

Symptoms.—True hematoma is most apt to occur in persons of advanced years, rarely before middle age. The tumorlike swelling appears suddenly, and is attended by the other usual signs of inflammation—redness and pain. Sometimes congestion and burning pain precede the swelling by several hours. The first appearance of swelling is usually within the concha, and it spreads rapidly, according to the amount of blood effused, until it may cover the entire anterior surface of the auricle. Gradually the color changes from a bright red to a bluish red, and finally to a livid hue.

TRAUMATIC CYST.—Hartmann first called attention to the fact that many of the cases reported as othematoma were not in reality blood tumors. He pointed out other differences, however, than the nature of the contained fluid, and insisted on establishing a separate class of these cysts, which he differentiated from hematoma as follows: They occur in the middle period of life, and generally in healthy, robust individuals; the onset is gradual, and not attended by pain or redness; the appearance of the skin covering the swollen area may be perfectly normal; the subsidence of the swelling is not attended by much deformity.

PERICHONDRITIS.—The cases which fall under this heading would seem to form something of a connecting link between the two classes described above. They are distinctly inflammatory in nature. The course of formation is somewhat less rapid than that of a hematoma, but the accompanying redness, heat, and pain are more severe. The exudate is more like that of the cysts, differing only in the amount of inflammatory elements present, yet the resulting deformity is very similar to that following hematoma.

Prognosis.—It seems to have been generally accepted that the occurrence of hematoma in the insane presages a fatal termination of the case. In the sane, their appearance has no such disastrous significance. The possibility of preventing deformity is one of the most important considerations, and, as has been shown, the liability to deformity is greatest in hematoma and least in the cysts. The difficulty of accurately classifying the cases found in literature makes it hard to say what form of treatment promises the most satisfaction.

Treatment.—The prompt evacuation of the fluid, by aspiration or through a small incision at the most dependent portion of the swelling, is the first essential. As the sac collapses, small pledgets of sterile gauze, adapted as nearly as can be to the irregular anterior surface of the auricle, should be applied, a supporting pad placed behind the auricle, and over these dressings an elastic flannel bandage, carried around the head, to exert gentle pressure. The dressings should be changed daily, and any fluid which has collected during the intervening time removed through the old opening. When there is no longer a tendency to further exudation, and reunion between the cartilage and its covering has taken place, gentle massage should be inaugurated. Massage should, however, always be deferred until the pressure treatment has nearly or quite restored the normal contour of the auricle.

TUMORS OF THE AURICLE

While not of common occurrence, still occasionally primary tumor formation of the external ear demands surgical interference. Most frequently it is of a benign character, cancerous growths being very rare. Secondary

metastatic tumors of the auricle are but very infrequently met with. The neoplasm may have its origin in any part of the ear, and spread either from the meatus out onto the pinna, or from the auricle into the external auditory canal. The early recognition of a malignant neoplasm is of course important, in order that it may be promptly and thoroughly eradicated, as much as possible of the external ear preserved, and general metastases prevented.

Among the benign tumors are to be considered fibromata, papillomata, cystomata, angiomata, and osteomata.

FIBROMATA.—These most common of all the new formations of the ear start usually in the lobule, though a few instances of their occurrence in other portions of the auricle have been noted. While generally small, they may grow rapidly and attain a very considerable size, causing not only marked deformity but serious discomfort.

The pathogenesis is not very clear. Almost invariably there is the history of a preceding injury of the normal tissues, and, just as is true of the general condition known as keloid, there appears to be a pronounced predilection to this growth among the colored races. The condition is, consequently, encountered in the Southern States oftener than in the Northern, and is said to be particularly common among the South American negroes. The passing away of the fashion of wearing earrings, and with it the onetime general custom of piercing the ears of female children, has had the effect of greatly reducing the number of these fibromatous growths.

Pathology.—Microscopically they are composed of fibrous or fully developed connective tissue, mainly spindle-shaped cells, with some irregular forms of connective-

tissue cells and very few blood vessels. The clinical features are a hard, resistant feel, and a smooth, generally regular but sometimes lobulated surface. The ætiologic traumatism is seldom an incised wound, much more often a piercing of the tissue.

Prognosis.—The consensus of expressed opinion is that, even after apparently complete removal, there exists a decided tendency to recurrence. Personal experience is not in accord with this view. Extirpation is easily accomplished, and recurrence has been observed in but a trifling proportion of the cases operated upon.

Treatment.—The ordinary rules of plastic surgery apply to this, as to all forms of nonmalignant growth of the external ear. The entire removal of the tumor, with preservation of a symmetrical appearance of the ears, is desirable. In the majority of cases, the tumors being small and limited to the lobule, this is easily accomplished by an inverted V-shaped incision through the entire thickness of the lobe, on either side of the tumor, the margins of the cut being subsequently brought together and held by a collodion dressing. Sutures through the skin should be avoided, on account of the tendency to the development of new growths at the point of skin puncture. Occasionally the size of the tumor will render a more careful dissection necessary, in order to secure better flaps and to maintain a good appearance. Thin skin flaps can be dissected off the tumor mass, but great care must be exercised, as the skin is closely adherent to the tumor, to avoid including any of the fibrous tissue in the flap. Turning aside the flaps, all fibrous tissue should be cut away, and the flaps then adjusted and united by collodion dressing or adhesive straps. Primary union is the rule. By this

means the dangers of deformity and of recurrence are reduced to a minimum.

PAPILLOMATA.—These occur most frequently on the auricle in the form of the common skin warts, and may appear either singly or in numbers. Occasionally a horny protuberance, both in shape and consistence, is seen. They are never very large, and always consist of a mass of squamous or columnar epithelial cells, hypertrophied papillæ, with a small amount of fibrous trabecular tissue and an exceedingly limited blood supply.

Treatment.—Excision is the only thing to be thought of. Cauterization of the base will facilitate healthy granulation and prevent the possibility of recurrence. If the growth be pedunculated, it can be removed entire by the aid of curved scissors or bistoury. The galvano-cautery is sometimes used to accomplish excision and cauterization at the same time.

CYSTOMATA.—A great variety of new tumor formations might be included under this heading, ranging from the simple comedones, through the various sebaceous cysts, to the othematoma. Differing greatly in size, appearance, and character of contents, they are all, except the last-named class and the dermoids, simple retention cysts.

Ectodermal cysts of the auricle are of infrequent occurrence. In structure they are of two types: the epidermoid, whose wall is composed of smooth connective tissue covered with stratified squamous epithelium, and the true dermoid, in which the sac wall presents all the characteristics of skin. These cysts vary greatly in size, and their contents consist of desquamated epithelial cells alone, or in association with such tissues as fat, hair, and bone.

Treatment consists in removal of the contents, together with the sac wall, if possible, and obliteration of the sac by cauterization, or by the setting up of an adhesive inflammation.

ANGIOMATA.—These are tumor formations, progressive in character, and composed essentially of blood vessels. Three distinct forms are recognized: the vascular nævus, or simple angioma, the cavernous angioma, and lymphangioma. In the type known as cavernous there is, in addition to the mass of new-formed vessels, a connective-tissue framework inclosing large spaces filled with blood.

While not generally of a rapidly progressive nature, angiomata are not to be looked upon as altogether benign. Originating from misplaced elements of the vascular tissues, they may be located anywhere about the ear, and while always congenital, may not become apparent until some exciting agent provokes the dormant tissue to activity.

Symptoms.—When attention is first attracted to the growth it may have the appearance of a " birthmark " or a varicose spot, or, as has happened in one reported instance where the growth was deep in the canal, it may be mistaken for a furuncle. Perhaps the most common site for the location of these tumors about the ear is the anterior surface of the auricle, and here they spread more or less rapidly to cover the entire surface. As the growth increases in size its correct nature becomes apparent. The skin grows darker, until it assumes a deep purple color; the patient complains of a throbbing sensation, and in some instances pulsation is visible even to the point of allowing the counting of the pulse by mere observation,

and, particularly when lying down, the patient is disturbed by the noises of the blood current.

Prognosis.—When it is possible to make a complete removal of the vascular mass and to obliterate the afferent vessel that has been feeding it, the results should be perfect. There is no special risk attending the operation, and the only dangers of failure are found in the difficulties in the way of complete extirpation and the tendency to recurrence from unexcised portions of the tumor.

Treatment.—As indicated above, removal by surgical means affords the best prospect of success, and the object to be kept in mind, and to strive for, is complete extirpation. The details of the operation will vary according to the size and location of the tumor. The first object to be attained will be, wherever possible, the control of the vessel or vessels which supply the tumor with blood. To accomplish this, and to prevent its almost immediate reëstablishment by collateral circulation, it is wise to ligate the main trunk of the afferent vessel even though it be necessary to go some distance from the tumor mass to do so. For instance, if a large part of the auricle be involved, nothing short of ligation of the common carotid will give reasonable assurance of successful control; and this should certainly be done in all cases where it can be clearly demonstrated that pressure upon the carotid causes a diminution in the size of the tumor. For the smaller growths, ligation of the external carotid, anterior or posterior auricular, or internal maxillary arteries may suffice.

The second step will consist in the removal of the tumor that has, perhaps, now been reduced in size. If the skin is not involved, but simply covers the growth, it should be carefully dissected up and turned aside so as

to expose the mass, which, as far as possible, should be dissected out intact. Any suspicious particles of vascular tissue should be carefully removed by the curette or sharp spoon, and the skin replaced over the cartilage and held firmly in place by a sterile gauze dressing and pressure bandage. Where the skin has been invaded, it should also be removed, and surfaces of cartilage thus exposed covered by skin grafts.

Very little after-treatment is required if asepsis of the operation field has been maintained. Exuberant or sluggish granulations, in the process of new skin formation, may call for cauterizing or stimulating applications.

Osteomata.—True osteomata of the external auditory canal are, according to the pathologist's standard that they possess a structure resembling bone tissue produced from a congenital matrix of osteoblasts, very rare. In the literature bearing upon these growths, as seen in the external auditory canal, considerable confusion has resulted from efforts to divide them into two distinct groups, the one bearing the name hyperostosis being generally described as consisting of those bony hillocks of ivorylike structure which arise close to the annulus, and which seem to have no relationship to any preëxisting inflammatory disease of the ear; while the other, the exostoses, including only the more or less pedunculated tumors, usually of cancellous structure, appearing at or near the juncture of the cartilaginous and osseous portions of the canal. The first were thought to be generally congenital, whereas the latter were supposed to be the outcome of some inflammatory irritation. Such a differentiation has no authentic basis in fact, either clinically or histologically.

Pathology.—In structure these growths vary from a spongy, cancellous bony tissue to a dense, compact, ivory-like substance. Microscopic sections show them to be always composed of the elements of true bone, but the typical Haversian canal system is sometimes indistinguishable, and the architecture of the trabeculæ is irregular. True osteoma of the auditory canal wall has its origin in misplaced embryonic bone cells or in an abnormal overgrowth of osteoblastic tissue. The new growths of bone which occur after injury to or suppurative disease of the ear are of another character. Beginning as a periostitis, a circumscribed area of bone ulceration results from infection and impaired nutrition, and then, as the inflammatory process recedes, nature's effort at repair exceeds the required amount, and the excessive formation of new bone tissue constitutes a hyperplasia. At first the growth is rapid and the structure cellular, but having reached its limit in size, the character changes through the continued deposition of bone cells in the softer fibrous tissue and interspaces. These tumors are always benign, but may cause serious trouble on account of size and location.

Aetiology.—The one definite element that seems to be connected with the majority of cases of aural exostoses is the positive history, or reasonable probability, of some former irritative process which might have been responsible for a periostitis. Thus many patients have, or have had, a prolonged suppurative otitis media, while others present evidences of chronic dermatitis or eczema. In a surprisingly large number of instances, where no other cause could be ascertained, it has been noted that the patients were addicted to overmuch salt-water bathing.

Mr. Field first called attention to this, and other observers have pointed out the great frequency of these growths among those South Sea Islanders whose occupation compels them to spend a large part of their lives in the water. Here, through diving, the presence of water in the canal furnishes the necessary irritating influence. A much larger number of cases are seen now in England than in European countries or in America. A study of the skulls of the early inhabitants of the Western hemisphere, the Mound Builders and Peruvian Indians, leads us to the supposition that aural exostoses were much more common then than they are now.

Gout, rheumatism, syphilis, and chronic alcoholism have all been arraigned as causative factors, but in no instance has conclusive proof been furnished that the constitutional disease exerts any influence upon the bone production. Heredity has been noted in a few cases, but too seldom to be considered as a determining factor of any special importance.

Subjective Symptoms.—If small, and unaccompanied by inflammatory trouble, the bearer may be unaware of their existence. By their encroachment upon the lumen of the canal they facilitate its obstruction from accumulations of cerumen or epidermis, and may serve as an obstacle to the outflow of discharge resulting from a suppurative process in the middle ear, when an impairment of hearing or the occurrence of threatening middle-ear symptoms lead to examination and detection of the bony tumors and the consideration of the necessity for removal.

Objective Symptoms.—When the canal has been freed of cerumen or débris, inspection renders the diag-

nosis easy. Often the growth is situated near the **exter-**
nal meatus, more frequently at the junction of the **car-**
tilaginous and osseous portions of the external auditory
canal, and sometimes well toward the tympanic end of the
canal. They may be single or multiple, unilateral or
bilateral. Occasionally they lie so close to each other, or
so completely fill the canal, that even a very fine probe
cannot be passed beyond them. As a very narrow orifice
permits a fair degree of hearing, they are often not dis-
covered until they have reached a large size. In volume
and shape they vary greatly. The attachment to the canal
wall may be by a delicate pedicle or by a sessile base. The
skin covering is of a whitish or pearl-gray color.

Prognosis.—So far as the exostosis itself is con-
cerned, complete removal usually implies a cure. Cases
of recurrence are rare, but one recorded case occurred
after a lapse of years, during which time the patient had
passed a comfortable existence in the possession of good
hearing. When the diminished hearing is dependent solely
upon the bone obstruction, removal of the latter restores
to the ear its full function. In suppurative cases the
enlarged canal favors the treatment of the diseased tym-
panum; full restoration of hearing cannot be expected
where the transmitting mechanism has been greatly af-
fected. The operation is almost invariably safe and
beneficial, though sometimes exceedingly difficult when the
growth has a dense eburnate structure and a sessile
attachment.

Indications for Operation.—A long time ago some
one laid down the dictum that " an exostosis of the audi-
tory canal is not to be operated upon unless it completely
blocks the canal and interferes with the exit of pus from

a coexisting suppurative otitis media, thus endangering the life of the patient, or unless its obstruction to the entrance of sound waves is the cause of profound deafness in a person who is also, from any cause, deaf on the other side." Strange as it may appear, this counsel of non-operative intervention has been repeated by recent textbooks on otology, in spite of numerous papers that have meanwhile appeared giving the histories of cases successfully operated upon, and also notwithstanding the improvement in surgical methods during that period, and the oft-repeated pleadings of aurists of high standing for early operation. From a careful review of the literature of this subject there is certainly justification in taking issue with the objections to operation, and in urging the surgical treatment of these growths without waiting for them to become particularly, and perhaps dangerously, troublesome. When done early the operation is much simpler, and the operator has much better control of the field than when the canal is completely obstructed. When suppurative disease exists, its treatment is rendered more easy, and its cure more certain and permanent, by the prompt removal of the growth, even if there be a passageway still sufficiently large to permit the egress of pus. When there is no history of purulent otitis, either present or past, it is still better to operate early, and thus save the patient the worry and despondence attending the slow onset of deafness.

Treatment.—Surgical measures offer the only hope of success. The local application of irritants and escharotics is no longer advocated as a matter of choice. The advantages of extirpation are a painless single operation under anæsthesia and healing of the wound by primary

7

intention, as contrasted with the slow and usually painful destruction by caustics, followed by prolonged granulation and the possibility of recurrence because of incomplete removal. When a patient refuses operation, an effort may be made to enlarge the lumen of the canal by cauterization with silver nitrate, painting with iodine, or gradual dilatation with laminaria tents, but such methods are slow, unscientific, painful, and generally inefficient. Constitutional treatment should be employed where gout or syphilis is known to exist. Electrolysis has been employed in some cases with good results, and when the pedicle is very small and fragile the cold snare or the electric cautery snare may be successfully used.

If the tumor be near the orifice, or is pedunculated and deeply seated, it is best removed through the natural channel. When located far from the external orifice, and especially if the base be broad or more than one exostosis is present, it will be found safer and easier to operate by first detaching the auricle posteriorly and drawing it forward on the cheek so as to expose the short osseous auditory canal. This brings the tumor close to the operator, and enables him to manipulate his instruments with much greater precision. In every case careful measurements should be taken to ascertain the size of the neck or base of the growth; this may be done by means of a loop of malleable wire.

Either operation should be preceded by careful aseptic preparation. The entire auricle, cheek, and mastoid region should be thoroughly scrubbed with green soap and water. If the auricle is to be detached, the hair must be shaved from behind and above it for at least three centimeters. Scrubbing within the canal is not feasible, but with the

assistance of a cotton sponge or gauze swab the walls and external surface of the osteoma may be fairly well washed with soap and water, and should then be flushed with alcohol. Cleansing the soap from the face and auricle should be followed by rubbing these surfaces with gauze soaked in alcohol, and the disinfected surface covered with sterile gauze and bandage until the surgeon is ready to operate.

All instruments should, of course, be carefully steril- ized, and herein is found one of the principal advantages of the chisel or gouge over a drill. The engine, and its attachments necessary to the use of a drill, cannot be properly disinfected, and in manipulating the apparatus the operator is in constant danger of carrying infectious material from the machine and tubing to the point of his drill and thence to the operation site. If a drill is used when dealing with hard, ivorylike exostoses, it may be driven by foot power or by the electric motor; the former is slower but more easily controlled, while the latter does the work much quicker, requires less pressure upon the drill, and with a little practice in handling becomes equally safe.

When operating upon a sessile growth, through the meatus, the attempt should be made to dissect off the skin and periosteum first and to preserve these flaps for cov- ering the denuded bone surface after the underlying exos- tosis has been destroyed. Such a plastic operation saves much time and trouble in the after-treatment, where ex- uberant granulations are apt to be troublesome if a large bare area is left.

The subcutaneous method for the removal of exostoses through the canal takes advantage of the fact that the

exostosis has usually a smooth peripheral surface, with a light attachment of the surrounding soft tissues, and that the larger exostoses have a not inconsiderable center of diploetic tissue easily permeable. Under these circumstances it is possible, by dividing the integument on the proximate surface of the exostosis vertically and across its base, and chiseling the bone, from without inward, by means of a narrow-bladed gouge, to lift the separated bony growth and withdraw it through the opening in the integument, which, collapsing, forms a skin flap requiring only light packing for its retention in place and its adhesion.

Large exostoses, nearly filling the transverse lumen of the canal, may be removed in this manner, thus avoiding the reflection of the auricle forward, or the slow healing incident to the removal of the exostoses through the meatus by means of the chisel, curette, or burr, with more or less sacrifice of the protective integument. After operation the canal should be plugged with sterile cotton or gauze, for protection and to keep the skin flap in place.
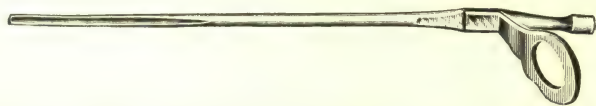
Fig. 13.—Chisel for use within the external auditory canal. ½ size.

The gouges or curved chisels for this purpose (Fig. 13) are twelve centimeters or more in length, of widths varying from one millimeter to three millimeters at the cutting end, and having near the head a flattened or ring handle set nearly at a right angle, by which the instrument can be held firmly between the thumb and forefinger of the left hand while the right wields a small mallet.

These chisels are also available for operations upon the labyrinth, and for removal of the outer epitympanic wall.

In the postaural operation the cartilaginous canal wall with the periosteal covering of the growth is easily drawn away with the auricle and the bone exposed. To do this, a semilunar incision is made from above the tip of the helix, downward, to the tip of the mastoid process, keeping close to the sulcus which marks the auricular attachment. The posterior auricular artery and vein will occasionally be encountered, as may also several branches, but the hemorrhage is easily controlled by application of hemostats and pressure with gauze sponges. With a periosteum elevator the auricle and cartilaginous canal wall are separated from the bone, and an assistant holds them well forward with a retractor. The chisels will have to be chosen with reference to the particular case in hand, very narrow ones being applicable in the largest number of cases. As a rule, it is best not to chip off the apex of the exostosis but to attack its base. This part is apt to be less dense, and the operation is thus shortened. Having removed the growth, together with all fragments of bone, and smoothed its former bed, the auricle is carefully replaced and gauze packed into the canal, to hold the periosteum in close apposition to the bony wall. The mastoid wound may be closed with a silver wire subcutaneous suture and a silver-foil dressing applied. On the fifth day, if everything has gone well, the dressing may be removed and the silver wire withdrawn. If no infection has occurred, the wound will have healed *per primam* and the resulting scar will be insignificant. A fresh dressing should be substituted for the old one in the canal, and a

simple protective dressing kept over all for a few days longer.

In those cases in which a suppurative otitis exists at the time of operation, the posterior wound will generally heal promptly provided free drainage through the canal has been maintained. Here the dressings should be changed earlier, depending upon the amount and character of the otorrhœa. In some instances it may be necessary to accompany the removal of the exostosis by some radical surgical measures directed to the cure of the suppurative process in the middle ear.

ATRESIA AND STENOSIS OF THE EXTERNAL AUDITORY CANAL

Total occlusion, or even permanent narrowing, of the meatus as the result of disease is not frequently met with. Not uncommonly such conditions occur with other malformations or developmental anomalies of the auricle. When observed as the result of postnatal changes, their origin is almost invariably found in a chronic inflammatory process associated with pronounced hyperplasia. In a few instances the obstruction has been due to traumatism with great destruction of tissue, and a consequent large cicatrix, or to faulty reattachment of a detached auricle.

Pathology.—Either a chronic suppurative otitis media or a chronic diffuse otitis externa may induce an inflammation of the periosteal lining of the external canal wall. Ulceration follows, which may involve only the periosteum, or may invade the deeper bony structures. Healing of such an area occurs by proliferation of cells to fill in the spaces of destruction, and if this proliferation occurs over a large region or throughout the length of the

canal, a stenosis, or narrowing of the canal lumen, results. Diminution of the canal lumen is also favored by subsequent contraction in the newly formed scar tissue. Total occlusion is the result of a similar process when the diseased area encircles the canal, or at least involves opposing surfaces of the canal wall.

It is evident that the new growth may consist of either skin, cartilage, bone, or a combination of these elements, and that occlusion may be complete or only partial. In the cases of osseous septum the plate is never quite complete, and careful search will usually reveal a channel through which a fine probe could be passed.

Symptoms.—Most of these patients appear seeking relief for a unilateral deafness; some, especially of the stenosis type, are discovered when they apply for treatment of a long-existent otorrhœa. All, except a few of traumatic origin, give the history of former middle-ear suppuration, which ceased with or without treatment, and was followed in time by deafness. This may be the only subjective symptom, but occasionally there is pain in or about the ear, commonly in front of the tragus, or else there is complaint of frequent attacks of earache. In a few instances retained pathologic secretions have sought an outlet through the mastoid, and, by infection of these cells or of the important neighboring structures, carried the more pronounced symptoms to another region.

Inspection by the aid of the speculum and good illumination shows the cause of trouble. When the atresia is due to obstruction near the external orifice, there may be merely a shallow depression to indicate the site of the meatus. If deeper, the canal will be, most likely, funnel-shaped. Purely cartilaginous or epidermal septa are much

more frequent than the variety containing bone, and are often located at a distance from the outer end of the canal, which in its external portion has an undiminished caliber. On the other hand, there may be a general thickening of the walls, with only a minute passageway, or, more commonly, an irregular contraction of the lumen by the variable swelling of different portions of the wall. Accumulation of cerumen, sometimes mixed with desquamated epithelium, in a stenosed canal may, by inducing deafness, tinnitus, or pain, first call attention to the existence of an abnormal meatus. Profound deafness to aërial sound conduction is naturally expected with complete atresia, yet two cases are reported in which fairly good hearing power remained in spite of total bilateral atresia satisfactorily demonstrated to be osseous in character.

Prognosis.—It is important to determine the exact nature of the obstruction, since the bony occlusions offer much greater difficulties in the way of treatment than do those of cartilaginous formation. An effort must be made also to ascertain the probable condition of the canal beyond the obstruction, particularly when the atresia occurred in childhood, as there may have been arrested development of the deeper structures.

Of eleven reported cases of atresia by bone, only three were operated upon, and failure to maintain an opening resulted in all of these. Out of thirty-one of cartilaginous or epidermal character, twenty-one were operated upon, with ultimate success in twenty, though it was sometimes difficult, and required prolonged attention, to preserve patency of the meatus.

Treatment.—Accumulated secretions, either ceruminous or purulent, should be carefully removed, partly as a

matter of facilitating a complete examination and partly as treatment. This may demand both time and skill, in order to accomplish the purpose without discomfort to the patient, as such ears are occasionally very sensitive. Medicinal applications intended to promote absorption of the hyperplastic tissue have been tried repeatedly in stenosis cases, but, as might have been expected, without any appreciable effect. If the canal be generally constricted, much good can be accomplished by the long-continued wearing of cotton or gauze plugs or of small rubber tubing, to exert constant pressure on the swollen walls. The absorbent plugs may be saturated with an ointment containing iodine or potassium iodide, to secure whatever of beneficial action may be hoped for from the employment of drugs. Greater benefit may be expected from the rubber, if judgment be used in selecting it of suitable size for the canal to be treated. Its caliber needs to be slightly larger than that of the contracted meatus, so that the expansile quality of the rubber tube will be kept constantly in play. By first stretching the tubing over a probe applicator it can be readily introduced to the desired extent, and upon withdrawing the probe the rubber contracts as far as possible toward its normal state.

More radical surgical measures are necessarily indicated in the treatment of atresia. The advisability of operating must be carefully considered in each case; the hearing power by bone conduction must be carefully tested, and the probable condition of the tympanum considered. If there be a reasonable hope of restoring some part of the hearing, an operation is justifiable, otherwise it is not. If the patient be an adult, and the history shows that the atresia originated during early childhood, an ab-

normal condition of the middle ear or inner end of the
meatus may be expected, and, even in cases where the
occlusion has resulted from a chronic suppurative process
of a later period in life, it is to be feared that there were
associated morbid changes affecting the deeper structures.

Where the occlusion is due to a septum of fibrous tis-
sue, it may be overcome either by complete resection of
the obstructing mass, or, when of delicate structure, by a
crucial division of the partition. The difficult features of
the problem are encountered in the effort to maintain a
permanently free canal. After the crucial incision, re-
union of the flaps can be prevented only by the insertion
of some form of stylet, to be worn for an indefinite period.
Exuberant granulations should be kept down by repeated
cauterization. It would seem to be better surgery to dis-
sect away the entire membrane whenever possible, and to
prevent its recurrence by cauterizing the exposed ring of
raw surface, or by seeking to cover this denuded area
with epithelium from the neighboring portions of the canal
or from skin grafts. This latter plan, first suggested by
Gifford,[1] does not seem to have been tried very often, but
has been uniformly successful. It is to be especially
recommended in all cases where considerable portions of
the wall have been left denuded by extensive resection.
The formation of a triangular skin flap through the atresic
ring, curetting out of the subcutaneous tissue and reposi-
tion of the flap, affords another satisfactory method.

A simple method of operation in cases of partial or
complete membranous atresia of the external auditory
canal, such as occur as the result of burns, mechanical

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[1] *Archives of Otology*, New York, vol. xxi, p. 316.

injuries, or in consequence of suppurative inflammation of the middle ear, consists in incising the atresic ring, which should first be centrally perforated if the closure of the canal is complete, carrying the incisions, two in number, from the same point within the ring divergently outward, and then peeling the triangular skin flap thus formed outward by means of a small curette, holding it in its inverted position by means of the speculum, or a flat probe, and then curetting away the subcutaneous basis of the ring, mainly cicatricial and secondary granulation tissue, down to the periosteum or bone; this having been done, the triangular flap should be replaced, and retained by light packing.

Where it is desirable to effect more than a partial removal of the atresia, other flaps may be made in the same manner, or an annular incision made within the atresic ring by means of a small knife having a triangular blade at a right angle to the shaft, similar to but stouter than the middle-ear knife for tenotomy of the tensor tympani.

The resultant angular skin flap should then be turned outward, the subjacent tissues curetted away, and the skin flap turned inward, pressed into place, and there retained by the introduction of a piece of thin rubber or metal or stout paper tubing. The turning of the annular flap outward is facilitated by one or more incisions made lengthwise of the external auditory canal.

If the occluding mass be partly composed of osseous tissue, its removal is a matter of greater difficulty and the prognosis is much less favorable; indeed, the small number of such operations that have been recorded in medical literature would seem to indicate a nearly hopeless pros-

pect. The drill, galvanocautery, or chisel and gouge will serve to get rid of the partition of bone, and, having effected the formation of a new canal, skin flaps from the canal wall should be turned in, or Thiersch grafts introduced to cover and protect the exposed surfaces. The grafts being properly placed, a bit of glass or rubber tubing is inserted in the canal and the space between this and the walls filled with some antiseptic powder. By the aid of better plastic surgery, more satisfactory results ought certainly to be secured in the future than have been generally obtained in the past.

FALSE MEMBRANES

In this connection a brief mention should be made of a type of occluding membrane that is occasionally met with, but which has a different origin and is of much less serious pathological consequence. The finding of a false membrane closely resembling in appearance the normal membrana tympani, situated usually from three millimeters to six millimeters external to it, has been reported by several writers. Of course, careful inspection demonstrates the absence of normal landmarks, and in some instances the membrane breaks down easily under the light pressure of a probe, being simply an epithelial cast of the closed inner end of the canal. It has been shown positively that in the healthy ear there is a normal movement of the epithelial cells of the canal wall, from within outward, to the external orifice, and it is sometimes possible to find an epithelial cast of this character traveling outward entire.

Still another variety of false membrane remains to be described which is met with rather more frequently. It

is located near the site of the proper tympanic membrane, but differs from that and from the epithelial cast above described both in appearance and in structure. Probably formed by the union of granulation tissue springing from opposite sides of the canal, and being vascular, it may bear a striking resemblance to the normal membrane. In such cases there is usually extensive or incomplete destruction of the true membrane, and some assistance in diagnosis may be obtained by autoinflation of the tympanum, the false membrane ballooning out under the air pressure.

Treatment.—Since a false membrane acts as a bar to admission of sonorous waves, and thus reduces the hearing, its removal is generally indicated. Resection of the entire tissue, followed, if necessary, by repeated cauterization of the base to prevent the organization of fresh granulations, constitutes the best method of treatment.

MALIGNANT TUMORS

Carcinomata.—In the present unsatisfactory state of our knowledge concerning the ætiology of cancerous growths we cannot do better than adopt Senn's definition of carcinoma as " an atypical proliferation of epithelial cells from a matrix of embryonic cells of congenital or postnatal origin." This tells practically all that is now known of the beginning and growth of these tumors. While much has been written lately of the possibility of these growths being due to a microbic infection, the most competent judges have not been satisfied that there is any solid basis for the germ theory. It has neither been proven nor disproven, and there is, perhaps, a reasonable possibility that the near future may bring forth some im-

portant development in support of this view, but at the present time we cannot consider it as having any practical bearing upon the ætiology. That heredity is often a factor in the production of carcinoma is generally admitted, but it is by no means a necessary agent. Injury or prolonged irritation, age, climatic influences, and possibly microbes, play a part in the causation.

Pathologically, the most important feature of carcinoma is the presence of masses of epithelial cells imbedded in a vascular connective tissue and surrounded by an area of small-celled infiltration, the infiltrate consisting of leucocytes and small, young epithelial cells. The wandering of these small cells into the lymph spaces, and thence to the glands and general lymphatic system, is the means by which carcinoma spreads, and we are reminded at once of the great importance of removing not only the evident swelling, but a considerable area round about it, and all the neighboring glands.

Microscopically, the epithelial cells always have the characteristic appearance of epithelial embryonic tissue, since in this abnormal new formation they never reach maturity. About the ear we have to deal chiefly with the squamous-celled type, which never grows as rapidly as the cylindrical or glandular cell forms, and is consequently more chronic and less virulently malignant than carcinoma in other situations.

The diagnosis of carcinoma of the auricle is not always easy, and while it must be constantly watched for, it must not be confused with lupus or syphilis. The condition of the glands may assist very materially in the diagnosis. In carcinoma the neighboring glands only are enlarged and hard, while in gumma the glandular swell-

ing is apt to be more general and more tender on pressure. In a case of doubt—and a case has been seen where an expert dermatologist could determine it in no other way—there is justification in postponing operation until a course of antisyphilitic treatment has been fairly tried. A small piece of the growth may be taken for microscopic examination, but it should be remembered that it is possible to make a serious mistake if this method is relied on solely. A small section may just miss an area of epithelial cells, and catch only what appears to be a granuloma, hence a negative finding is not proof that carcinoma does not exist. The finding of true carcinomatous tissue, of course, leaves no room for doubt.

SARCOMATA.—Of infrequent occurrence under any circumstances, sarcoma practically never makes its appearance about the auricle in adult life. Just the reverse is true of carcinoma, which is rarely seen in persons under thirty years of age. It is, too, the representative of the malignant growths of the connective tissues, or tissues of mesoblastic origin; hence the opportunity for its occurrence is limited about the auricle, where this type of tissue is represented in the main by cartilage. Injuries to the lobule sometimes result in tumor formation, that at first may be fibromatous in character and then undergo a sarcomatous degeneration. Occasionally a sarcoma appears in the auditory canal, beginning in the bony wall, but, while it is essentially a tumor of mesoblastic origin, it may very readily invade tissues of epiblastic origin.

Pathologically, different varieties of sarcomata may be distinguished, according to the character of the predominant connective-tissue cells in the growth. Thus, there is the spindle-celled sarcoma, in which the character

of the tumor is decided by the numerous embryonic connective-tissue cells of spindle shape and having a large nucleus; the small round-celled sarcoma, named from the presence of numerous round cells resembling the cells of granulation tissue, but distinguished by their large nucleus containing an abundant supply of chromatin; the giant-celled sarcoma, which, as its name implies, presents a group of very large cells with multiple nuclei; and, finally, a mixed-cell sarcoma, containing more than one of the above features. In all there is a grouping of the cancer cells about the blood vessels. The round-celled type is the one that has been generally noted in the sarcomata of the external ear.

What has been said of the ætiology of carcinoma applies equally well to sarcoma. Some influence is required to stimulate into activity tissue cells, or to introduce, by traumatism, a postnatal matrix of granulation tissue, which proceeds to active proliferation.

Diagnosis.—This may be made from the history of the growth, and its appearance, but an absolutely certain diagnosis depends upon microscopic examination. Aside from considering the age of the patient, some assistance may be found in ascertaining the manner in which the tumor made its first appearance, whether it began as an ulcer of the skin or as a lump under the skin. The former would, of course, point to carcinoma. As a rule, sarcoma grows more rapidly than carcinoma.

The prognosis depends entirely upon the possibility of complete removal of the tumor and any local extensions, and the absence at the time of any metastases. The last point is difficult to prove in any case, but the earlier the patient is seen after the first symptoms of new growth

have appeared, the less is the liability of absorption into the general system having taken place.

Treatment.—This consists in the prompt application of surgical measures, and these are to be instituted only when there is a reasonable prospect of being able to eradicate the entire growth. In order to do this, it may be necessary to remove the entire auricle, together with the cartilaginous wall of the external canal. The small postauricular glands should be carefully inspected, and, if necessary, removed. No definite operative technique can be given, each case requiring treatment according to the location of the tumor and the amount of tissue involved. The rules of plastic surgery apply, and every effort must be made to cover the denuded parts with healthy skin by flaps or by Thirsch grafts. The after-treatment will be as important as the operative procedures, and constant care must be taken to prevent a recurrence, the knife or actual cautery being called into requisition if needed to destroy any exuberant granulation. Recurrent and inoperable cases may be subjected to treatment by the Röntgen rays, and some benefit expected, but at the present moment there is no positive proof that permanent cures have resulted from this measure, except when used upon superficial epitheliomata.

FOREIGN BODIES IN THE EXTERNAL AUDITORY CANAL

An attempt to enumerate the various objects that have been found in the auditory canal would be an unprofitable task, albeit the resulting list would constitute a very large and interesting collection. All kinds of inanimate bodies, from pins and buttons, seeds and onion tops, to glass beads or wooden balls and lead bullets, and a collection of

8

animal life varying from maggots to cockroaches, have been reported. In the vast majority of instances coming under our observation the foreign substance has been purposely introduced into the canal, sometimes by children in the course of play, occasionally by adults in their effort to treat an earache or toothache. The presence of the insects is usually due to the accidental flying or wandering in of bugs, or to the development of the larvæ of flies in the products of an existing purulent otitis media.

Symptoms.—Dependent upon the character of the foreign substance introduced into the canal, the method of its introduction and the amount of injury produced thereby, the subjective and objective symptoms vary widely. Sharp-pointed or jagged objects driven in forcibly, or corrosive chemicals, may cause serious injury to the canal wall or to the tympanic membrane, and the infective inflammation that so frequently follows such trauma can lead to serious consequences. In these cases pain is a marked feature. More commonly the offending object is of an innocent nature, and causes no great trouble even when left in place for a long period. Interference with hearing will depend much upon the degree of occlusion of the canal either by the foreign body or the inflammatory swelling, or upon the amount of harm done to the drum membrane and ossicles. Live insects in the ear may occasion great discomfort through crawling over the sensitive membrane, or even fastening their tentacles into it. Sometimes foreign bodies that have been retained for a long time, without causing any direct local disturbances, will be responsible for reflex phenomena of various types and degrees, and quite persistent in character.

Diagnosis.—It will not do to accept the statements of patients or friends that there is a foreign body in the ear. A child may claim to have inserted something, or an adult may know that an object was accidentally introduced, and yet careful search will reveal nothing, the object having escaped from the ear unnoticed. Too often the blind endeavors of a careless, ignorant physician to extract a supposititious foreign body have led to mischievous results. In every instance the first step, after hearing the history of supposed existence of a foreign body in the canal, should be a careful examination under bright illumination. Great swelling of the walls may render an investigation difficult, but having determined that a foreign body is present, its location should be estimated as accurately as possible, especially with relation to the tympanum, as well as its character, size, form, and density.

Prognosis.—Removal can almost always be successfully accomplished, and if important structures have not been injured by the entrance of the object, or by ill-advised efforts at its extraction, there should be no damage to function. Wherever the transmitting apparatus has been wounded, or infection set up, the possibilities of danger from such sources must be considered. A review of reported cases, as well as personal experience, teaches that far more serious effects have followed unskillful efforts at extraction than have ever resulted from the introduction, or mere presence, of foreign bodies in the ear.

Treatment.—In a vast literature on this topic, all writers agree that the safest and most successful instrument to be employed is the syringe. While there may be

special occasions, owing to the peculiar character of the object or its position, when a skilled physician would be justified in appealing at once to other instruments, it may be declared a general law, applicable to the specialist and novice alike, that a thorough, painstaking use of the syringe should precede any operative measures. There is room for much ingenuity in the employment of the syringe, and, when displayed, a satisfactory result will often obtain where a fruitless outcome seemed imminent, or where failure had attended its use by less skilled hands. Simply forcing fluid into the canal does not meet the requirements. The best means of getting the water beyond the object must be considered, in order that the return flow may exert the greatest influence in dislodging the object. At times this may be accomplished by the aid of a special nozzle, one that will inject a flat, ribbonlike stream along the canal wall. Made to fit the ordinary syringe, the nozzle is flattened near the tip and curved on the flat so as to adapt it better to the shape of the canal. The same syringe is also serviceable in dealing with a dense ceruminous plug, tending to force a channel along the wall instead of through the central portion of the mass.

When persistent syringing fails to remove the obstruction, it is necessary to resort to physical measures permitting the more direct exercise of force upon it. The choice of an instrument will be determined largely by the conditions confronting the operator in any particular case. The blunt hook or wire snare may be used for hard substances, and the toothed forceps or slender bullet forceps for more easily penetrable bodies. As a general thing forceps are to be avoided, unless the foreign body is in

the cartilaginous portion of the canal, or until it has been brought there by other means, or unless the object is known to be of such a nature that it can be surely grasped and held by the blades. The danger lies in the possibility that in trying to close around the object it may be pushed deeper into the canal.

A small group of cases remains to which these measures would not be applicable or in which failure has followed their trial. Here success can usually be attained by reflection forward of the auricle by a long curved incision over the mastoid, and, when necessary, cutting through the posterior bony wall of the canal and external wall of the attic, as in the operation for tympanic exenteration. In the case of bullets which have spread at their inner end, a channel in the bone should be chiseled of sufficient diameter to permit their extraction with the use of mechanical force.

ACUTE CIRCUMSCRIBED INFLAMMATION OF THE EXTERNAL AUDITORY CANAL (FURUNCLE)

A furuncle, or boil, may be defined as a conical or hemispherical inflammatory nodule arising in the deeper layers of the skin and subcutaneous tissue, inclosing a central slough or core, surrounded by a mass of exudative material, pus, cells, and serum. Furunculosis of the external auditory canal being seen most frequently during the spring or autumn months, has led some writers to speak of the disease as appearing at times in epidemics. Such an idea can hardly be seriously entertained, however, and the probable explanation of the greater number of cases occurring at such times is found in the simple fact that most people show their lowest state of vitality

during those seasons, and are then least able to resist any slight infection.

Furuncle is always of bacterial origin, but as yet no specific organism has been isolated, although numerous attempts at so doing have been made. It would appear from published reports that any of the pyogenic organisms might be causative agents, and several have been frequently found mixed in one culture. Thus Löwenberg found the Staphylococcus pyogenes albus in every case but one of those examined by him, but in the majority of cases Staphylococcus pyogenes aureus or citreus was also present, most frequently the former. Other observers have found the Staphylococcus aureus to be the bacterium concerned in the great majority of cases. The difficulties in obtaining an uncontaminated culture from such an inaccessible region as the auditory canal must be borne in mind, but the above findings are very suggestive when considered in connection with the discovery of Dr. Welch, that the skin is the constant habitat of one variety of the staphylococcus, to which he gave the name of Staphylococcus epidermidis albus. This organism can almost always be found in the deeper parts of the corium, in the hair follicles and sudoriparous glands of normal healthy skin, and it is in just these positions that boils originate. Any other bacteria may, of course, reach the same location by traversing these channels from their openings on the skin surface.

While bacteria undoubtedly play the leading part in causing this acute inflammation, the influence of certain secondary ætiological factors must be admitted, especially if it is assumed that the skin coccus is an important one of these germs. Such factors are, a general dyscrasia

with predisposition to inflammatory trouble of this character, some underlying cause that favors suppurative processes, or some form of mechanical irritation to act as an excitant. The existence of a slight dermatitis of the canal, leading to the habit of scratching or rubbing the surface with foreign bodies, is a not infrequent precedence to attacks of furunculosis.

Symptoms.—The first to be noticed and, throughout the course of the affection, the prominent subjective symptom is pain. This is always severe, and in some instances excruciatingly so, the patient being unable to sleep or rest. Loss of appetite, general malaise, and constipation are usually noticed, and there may be some febrile symptoms, although the temperature seldom rises more than one or two degrees. The hearing is diminished in direct proportion to the obstruction of the canal or the presence of myringitis from extension.

Objectively, the early stage is marked by a localized inflamed spot which is exquisitely tender; the second stage by circumscribed swelling of a conical shape; and the last stage by rupture of the boil and the outflow of pus, with a craterlike opening in the apex of the swelling. Subsidence of the tumor follows very shortly after the abscess has discharged freely, but the course of the inflammation, from commencing swelling to spontaneous rupture, covers, on an average, a period of six or seven days. The severe pain ceases completely, or diminishes gradually, after opening of the abscess either by rupture or puncture. The most common site for a furuncle is on the floor or on the posterior wall of the cartilaginous portion of the canal, not infrequently on the inner surface of the tragus. Two or more may be present at the same time, and if they

occupy opposite locations they not only soon occlude the canal, but produce increased pain by the pressure of their opposing surfaces. Involvement of the deeper tissues is unusual, but such a possibility must not be forgotten, and necrosis of the osseous external auditory canal wall may be a sequel.

Diagnosis.—In general there is no difficulty in recognizing the true state of affairs, but occasionally there is a confusing picture. From the history of pronounced pain in the ear and loss of sleep, either a boil or middle-ear inflammation may be at once suspected. The diagnosis can often be made as soon as the auricle is touched and before the speculum is inserted, by the wincing of the patient when this is attempted. Any manipulation of the auricle is attended by stretching of the cartilaginous wall, causing sharp pain if a furuncle be present in any part of the canal, while in a case of otitis media no such effect is produced. The swelling may render it impossible to view the tympanic membrane, which might give evidence of a coexistent otitis media that has not yet reached the stage of suppuration and rupture, but which is accountable for part of the discomfort. In furunculosis there is often swelling of the lymphatic glands in the neighborhood, and those about the mastoid tip and angle of the jaw are apt to be very sensitive to pressure. In some such cases, especially if there be œdema of the mastoid region, it is possible to mistake this for evidence of mastoid disease. It is often possible in furunculosis to get tenderness, by pressure, over the mastoid process, but this is due to disturbance of the auricle and canal wall, not to direct pressure on the bone.

Prognosis.—Relief from pain and healing of the lesion usually follows rapidly upon the institution of proper treatment. There is a strong tendency to infective recurrence, and local antisepsis as well as constitutional treatment may be required for a prolonged period.

Treatment.—Antiphlogistic measures consist of local depletion by means of the artificial leech, applied just in front of the tragus or just over the tip of the mastoid process, and the application of ice to the posterior surface of the auricle.

Heat, properly applied, tends to relieve pain and advance the period of suppuration. Dry heat can be applied by means of the Japanese warming boxes, wrapped in a napkin and held in place by a bandage over the head, or by resting the head on a hot-water bottle or warmed pillow. The general application of moist heat should be avoided, but the canal should be frequently irrigated with hot water, and stopped with dry cotton in the intervals.

In default of irrigation and dry heat, the canal should be dressed with a light cotton wick saturated with carbolized glycerin. Phenol is not only antiseptic, but anæsthetic, and is quite absorbable by the skin. A good preparation is the camphor-phenol, made by combining fifty-five parts of pure gum camphor with forty-five parts of carbolic-acid crystals. Pain may be so severe as to demand the administration of morphine. Tonics and rest are indicated in all cases. When appearances point clearly to the presence of pus, the use of the knife is indicated. Experience proves that in many, if not in most, instances efforts to abort the process are destined to failure, and that an early operation is really the most conservative

treatment, in that it saves the patient hours of discomfort, and secures a quicker cure with less danger of a spreading affection. In either event, when operation is determined upon, the endeavor should be to make a clean, deep incision, with an opening large enough to permit the easy, free, and complete evacuation of the inflammatory contents. For this purpose a strong, sharp, narrow blade is required. The auricle and external canal should be cleansed as thoroughly as possible by such scrubbing as is permissible without increasing pain. Local anæsthesia may be effected by means of the chloride of ethyl spray, or, as the operation is of short duration, the use of nitrous-oxide gas or primary etherization will suffice. The location of the boil should be carefully determined, and the incision made by plunging the point of the knife to its depth and enlarging the incision as the blade is withdrawn. In some positions of the boil it will be necessary to use the edge instead of the point of the blade to make the first cut, but, whenever possible, the operation should be made complete at one stroke. After cessation of concomitant bleeding, moderate pressure on the swelling with a firm probe will often assist in discharging the core or inflammatory débris. The canal should be cleansed by irrigation, and the swollen tissues, especially the open wound, mopped with camphor-phenol, carbolized glycerin, or pure carbolic acid. Such an application destroys all the microbes on the surface, and effectually prevents infection of the neighboring parts. A cotton or gauze wick soaked in carbolized glycerin or camphor-phenol should be inserted into the canal, and whatever constitutional treatment or hygienic precautions seem advisable should be prescribed. A fresh dressing will be required in from

twelve to twenty-four hours, and may have to be repeated once or twice a day for several days. Where it is impossible to see the patient so frequently, an antiseptic wash, applied by means of a soft-rubber syringe, should be ordered for use twice daily, after removal of the first dressing.

CHAPTER IV

DISEASES OF THE TYMPANIC MEMBRANE AND TYMPANUM

THE scope of this work being limited to the surgery of the ear, it is neither expedient nor desirable to enter upon a complete and exhaustive consideration of all the various affections of that organ. Here, as in the preceding chapter, attention will be given only to those diseases which may, at some stage of their career, claim or demand operative intervention. For a full review of the ætiology, progress, and medicinal treatment of such affections, and dissertations upon such abnormalities, injuries, or diseases of the middle ear as rarely, if ever, require surgical attention, the reader is referred to the many excellent treatises on diseases of the ear. It would not, however, seem sufficient simply to describe the several operations performed in this region without first having presented some concise statement of the conditions which necessitate their employment and the indications which determine their applicability. It is, in consequence, deemed advisable to offer first a brief essay on each of these affections, as viewed by the surgeon, and to follow with a specific detailed account of each operation.

INFLAMMATIONS OF THE MEMBRANA TYMPANI

(*Myringitis Acuta et Chronica.*)

Owing to the similarity of the pictures presented by acute inflammation of the tympanic membrane alone, and by acute inflammation of the tympanum with involvement of the membrane, the former condition probably often fails of recognition as a distinctly limited process. The histologic structure of this membrane, and its peculiar anatomic position as the partition between the external auditory canal and the tympanic cavity, and the relation of its blood supply to that of both the middle and external ear, render it peculiarly liable to inflammatory affections spreading from the walls of the canal, or of the tympanum, through direct continuity. Its structure comprises four distinct layers of essentially different tissues. Externally, the epidermal and dermal layers are directly continuous with the same lining membranes of the external canal walls. Medially is the basic portion of the membrane—the substantia propria—a double layer of fibrous tissue firmly attached to the annulus tympanicus and to the malleus handle, and finally, internally, is the stratum of mucous membrane that forms part of the general pouch which passes from the nasopharynx to the tympanolaryngeal tube and tympanic spaces. Invasion of the dermal and mucous layers by the extension of pathologic processes from contiguous similar tissues is quite common, but it is only the not infrequently acute primary infection, limited to these portions of the membrane, which will be considered at this time.

Aetiology.—In many instances it is not possible to ascertain the active agent in the causation of an acute

primary myringitis. Cold water or other irritating substances introduced into the canal, either by accident or design, may inaugurate a simple type of inflammation, but they act probably not as direct irritants so much as predisposing agents of susceptibility to the attacks of pathogenic microörganisms.

Pathology.—The earliest objective sign of an acute inflammation of the membrane is a hyperæmic condition along the malleus handle, due to congestion of the plexus of the arteria manubrium mallei. This is followed by the appearance of a vascular circle about the periphery, and this by a general and complete injection of the entire membrane through the rapidly advancing appearance of anastomotic branches from the periphery toward the manubrium, and the injection of the capillary meshes in the dermoid and mucous layers. Following this, exudation begins, all the layers tend to become infiltrated, and the membrane is correspondingly thickened. The substantia propria is least affected in acute cases, its close fibrous structure offering most resistance to the infiltrate. In the dermis there is a tendency to the formation of small

Fig. 14.—Large serous bulla with small ecchymoses and peripheral injection of blood vessels in a case of acute congestion of the middle ear.

ecchymotic spots, as the result of diapedesis or of rupture of the thin-walled vessels, and, owing to the ease with which the derma may be separated from the substantia propria, effusion of serum or of blood causes the formation of circumscribed bullæ (Fig. 14). Resorption of the fluid contents of these bullæ may take place and a normal condition of the membrane be restored, or the inflammation may progress to the stage of suppuration and

ulceration of the dermis, or to the perforation of the whole membrane.

When involvement of the tympanic membrane has occurred, through direct extension from the external auditory canal of an eczematous inflammation or a diffuse otitis externa, only the derma, as a rule, is affected, and the process is limited to hyperæmia and infiltration of the tympanic membrane and exfoliation of its epidermis.

Should the disease be more severe, and a superficial ulcerative process continue for any length of time, granulation tissue is prone to appear on the surface of the membrane.

Necrotic perforation of the membrane is more likely to occur in those cases in which the entire structure has been invaded by an active pyogenic organism, no matter whether the invader entered by way of the external canal or the tympanum. Repair is brought about by the casting off of detritus, the absorption of inflammatory exudate, and the formation of scar tissue to replace that which has been destroyed.

In the chronic form, where nutrition of the tissues, especially the central layer of the membrane, has long been interfered with, calcareous degeneration of small areas is frequently discovered after healing is complete.

Symptoms.—When observed in the very earliest stages it will be noticed that the congestion begins along the handle of the malleus and the peripheral portions of the membrane. As the inflammation progresses, the hyperæmia gradually extends in all directions until the entire membrane is reddened and swollen and the usually distinct landmarks are obliterated; the light cone is first lost to sight, and soon the definite outline of the handle and

short process of the malleus are obscured. One or more hemorrhagic spots may appear, from the effusion of blood under the dermal layer, or, if a collection of pus be formed in a similar locality, yellowish bullæ or pustules will be seen. It is always difficult and often impossible, unless they are very much circumscribed, to say whether such bulgings of the membrane are limited to accumulated secretions within the tissues of the membrane itself, or whether they represent larger collections in the cavity.

The subjective symptoms are a sensation of fullness, tinnitus, and pain, the latter sometimes very severe and radiating over the whole side of the head. The pain is usually continuous until spontaneous rupture of the pustules, or their incision, relieves the tension, but occasionally it will be paroxysmal or intermittent.

Diagnosis.—It will be gathered from what has been said that a positive diagnosis can be made only when inspection is permitted in the early stage of the inflammatory process. Later on it becomes a difficult matter to determine with precision whether the condition is myringitis or otitis media. The appearances of the membrane are the same in both affections, and the subjective symptoms are in the main alike, but the diagnosis may occasionally be made on the basis of hearing tests. In myringitis the hearing is but slightly if at all affected, while in otitis media there is usually a distinct rise in the lower tone limits; the presence of an exudate in the tympanum, by hampering the movements of the transmitting apparatus, impairs its function to a far greater extent than does the mere thickening of the membrana vibrans.

Prognosis.—If promptly recognized and properly treated this affection is short-lived, the natural tendency

being to spontaneous recovery. Sometimes, owing perhaps mainly to impoverished general health, an ulceration of the membrane results and polypoid tissue grows therefrom, or the infection invades the middle ear and opens the way for all the complications of suppurative otitis media. Persistent and sluggish ulcers of the membrane are much more prone to occur with chronic diffuse otitis externa, or with one of the fungoid infections of the canal, however, than with an acute inflammatory invasion by pyogenic organisms.

Treatment.—The purely medicinal remedies that may be employed, particularly in the early stages of the affection, will not be discussed here. Antiphlogistic measures, topical applications for the relief of pain, and the employment of agents for the promotion of absorption of inflammatory products, all have their proper place in the treatment, and, if used at the favorable moment, serve a useful purpose. Two surgical measures may be called for: local bloodletting to check the progress of inflammation, and paracentesis, for the evacuation of serous or purulent effusions. The first indication is met by the application of the leech in front of the tragus, and the second by a clean incision into the bulging area or bulla. If it is evident that the bulging represents an effusion into the tissues of the membrane, and not an accumulation in the tympanum, partial paracentesis should be carefully performed to evacuate the secretion, without perforating the entire thickness of the membrane and thus endangering deeper structures by infection. When in doubt, perform a complete paracentesis. It is not to be understood, however, that incision of the membrane is recommended only when bulging thereof is apparent. Here, as in general

9

cellulitis, an early cutting affords relief from pain, re-
duces the hyperæmia, checks the inflammatory advance,
and proves itself a conservative measure in that less tissue
is destroyed than would result from nature's effort at
relief, and more rapid healing ensues. As in the case of
acute suppurative otitis media, doubt may arise as to the
proper moment to institute surgical intervention. A good
working rule to observe at such times is, that one errs, if
at all, on the safe side when he decides to cut. A properly
performed, clean paracentesis practically never causes
trouble, and frequently does great good, while delay may
favor a prolongation of the disease, resulting in great
destruction of tissue and impairment of hearing conse-
quent upon the formation of adhesions.

INFLAMMATION OF THE MIDDLE EAR

(*Otitis Media.*)

An inflammation within the tympanum is the condition
found to exist in approximately sixty-five per cent of all
cases of ear disease, and the importance of a proper con-
sideration of these inflammations is further enhanced by
the fact that the evil consequences of tympanitis may be
more numerous and more serious than those of any other
class of aural affections. Not only may the function of
the organ be impaired by the diminished mobility of the
sound-transmitting apparatus, brought about by inflam-
matory changes or by the secondary involvement of the
auditory nerve, but in many instances important neigh-
boring structures may suffer from extension of the in-
flammation, and even life itself may be endangered. On
pathologic grounds, as well as for clinical convenience, it
is necessary to classify the inflammatory affections of the

tympanum, separating them into distinctive groups according to the character of the process and the nature of the lesions produced. Anatomic and histologic considerations predetermine the fact that all acute inflammations of the middle ear must be of the so-called catarrhal type, but on account of differences in the causative factors, and because of wide variations in the constitution of the exudates, the form assumed is subject to great variations. If the morbid influence be only mechanical or thermal, or if it be not intensely active, only a serous or mucous exudate will result. If, on the other hand, the disturbing agent be such as to cause destruction of tissue, as do some of the more virulent pathogenic microörganisms, or if the powers of local resistance be markedly reduced, a purulency will be induced which may be accompanied by extensive necrosis and a tendency to invasion of adjacent organs. Between these two extremes may be observed all the grades of secretory inflammation to which a mucous membrane can be subjected, and in accordance with these variations, and with the variant clinical picture produced thereby, an elaborate classification of middle-ear inflammation has arisen which, while generally superfluous, is sometimes extremely valuable for minute differentiation. For the needs of this work such a detailed scheme is unnecessary, and it would seem to be sufficient here, as a basis for surgical consideration, to divide all the inflammations of the middle ear into two large groups:

1. Simple, nonsuppurative, sero-mucous, and plastic exudative forms, which are usually classed under the broad heading of catarrhal inflammation (otitis media catarrhalis); and

2. Those cases in which the formation of pus is an

essential element, the suppurative inflammations
(otitis media purulentæ).

This has the advantage of being a simple classifica-
tion, and also a practical one for the clinician; the use of
the term " catarrhal," to distinguish the first group, being
not in strict accord with modern pathology. It is per-
fectly feasible for a serous exudate, even without infec-
tion by bacteria, to take on the attributes of purulency,
and a microscopic study of the lesions of middle-ear in-
flammations shows, whether suppuration has existed or
not, that the variations are of degree rather than of kind.
The severity of the inflammation and the duration of its
existence will, in a large measure, determine the nature
of the lesions produced and the impairment of function
resulting, and these differences may be fully considered
as distinct steps in the structural changes of each group,
without making a more elaborate distinction.

EXUDATIVE AND PLASTIC NONSUPPURATIVE INFLAMMA-
TION.—Aetiology.—Primary serous or sero-mucous non-
suppurative disease of the tympanum is almost invariably
said to be due to " exposure to cold." Cold winds blowing
upon the ear, cold water entering the external canal dur-
ing the bath, sudden climatic or temperature changes, and
various similar agencies, are described as playing the
active part. In many cases, however, there exists an
admitted passive factor in the presence of one of the
well-recognized secretory diatheses. With tuberculosis,
syphilis, or gout as predisposing causes, or with a low-
ered state of local resistance, any sudden disturbance of
the normal vasomotor balance within the tympanum will
lead to a secretory form of inflammation of the mucous
membrane. Microörganisms are sometimes found in the

resulting exudate, and, indeed, while the serous and sero-fibrinous inflammations may be caused by thermal and chemical influences as well as by bacteria, they are probably most frequently the result of infection. The pneumococcus and staphylococcus often occasion such mild types of inflammation, but when such organisms are really active the inflammation is apt to take on the characteristics of purulency, and consequently pass out of the class under consideration.

But the vast majority of simple exudative middle-ear disorders are of secondary rather than of primary occurrence, and have their origin in similar affections of the nasal or nasopharyngeal mucous membranes. The transmission of the disease from one point to another may be accomplished by its spread through directly contiguous tissue, or some of the irritating secretion may be conveyed from the pharynx to the tympanic cavity by forcible inflation through the tympanopharyngeal tube. Still another explanation, applicable to a large proportion of cases, is the continuous irritation of the tubal and tympanic mucous membranes, the obstruction to proper ventilation of the drum cavity, and the interference with the blood supply of these parts, which usually accompany adenoid growths in the pharyngeal vault, hypertrophied turbinates, and enlarged or congested tonsils.

Pathology.—Exudative inflammations are distinguished from other varieties by the one essential that the exudate has free access to the surface of the involved tissue, and flows from the same, mixed with desquamated portions thereof. The form varies with the quality of the exudate. If this consists essentially of fluid, while the cellular constituents are insignificant, the inflammation is

called serous; when the exudation of fluid on the surface of a mucous membrane is associated with a marked mucoid degeneration of the superficial epithelium and of the mucous glands, it is called mucous; if leucocytes are present in large number, sufficient to impart a white or yellowish-white color to the exudate, the condition is known as purulent; if in such a fluid exudate there occurs a deposition of fibrin or coagulum, it is designated as fibrinous.

Whatever the morbific excitant to inflammation may be, there is always a condition of local tissue degeneration, followed by alteration in the circulation and by exudation. The first effect of a localized tissue injury is an active hyperæmia of the part, on account of the dilatation of the lumen of its blood vessels, and this vascular dilatation may be the result of either stimulation of the vasodilators or paralysis of the vasoconstrictors. With the increase in caliber of the vessels there is a coincident slowing of the blood current and the commencement of a pathologic exudate; as the flow diminishes in speed, the solid elements of the blood must, in compliance with physical laws, leave the center of the stream and accumulate at its periphery—that is, along the walls of the blood vessels; and as these vessel walls have at the same time become changed in structure, so as to show an increased permeability, the active corpuscular elements, together with red blood corpuscles and the serous fluid, pass out through the cell interstices. These migratory white blood corpuscles, chiefly the polynuclear forms of leucocytes, the red blood corpuscles, the extravasated serum, and the degenerated and desquamated tissue cells, constitute the inflammatory exudate, the composition of which is de-

pendent partly upon the especial property of the affected vessels, partly upon the histologic structure of the inflamed tissues, and to some extent upon the amount of damage inflicted upon the vessel walls.

In exudative disease of the middle ear, the amount of injury perpetrated upon that organ and the extent of interference with its functions depend very largely upon the composition of the exudate and the completeness with which it may be removed from the tympanum by drainage or by natural processes of healing. Bearing these two points in mind, the widely different lesions that characterize this disease are easily explainable. Simple serous or mucous secretions are accompanied by but little destruction of tissue or impairment of function, are readily absorbable when the course of inflammation has ceased, and leave no permanent pathologic effects. The most serious of the exudative conditions in this small chamber, with its contained delicate mechanism, is the exudate which contains fibrinogenic substances. If the fluid exudate contains fibrinogen and fibrin ferment, and coagulation occurs, there will result a deposition of fibrin on the surface of, or within, the tissue that is infiltrated with the exudate. The site of inflammatory lesion may be limited to any small portion of the tympanic walls, the membrana tympani, or the ossicular coverings, or it may be so extensive as to involve the entire tympanum and its contents. An exudate upon the walls of the tympanum only, even though it fails of absorption and becomes organized, may occasion no interference with hearing; but a similar deposit upon the tympanic membrane, or the ossicles, by its weight alone, must mechanically diminish their mobility. Furthermore, an exudate, no matter in

what part of the cavity it may be situated, that sends out threads of fibrin to become attached to the membrane or ossicles, and perhaps binds these to each other or to the tympanic walls, must produce still greater impairment of motion, and be a further hindrance to the transmission of sound waves to the terminal auditory apparatus.

With the removal of the cause of inflammation and the cessation of the pathologic exudation, the absorption of the exudate occurs easily and quickly in many cases, the serous and less frequently the fibrinous exudate being rapidly removed by the lymphatic and vascular channels. Nature, failing in this method, tries to bring about resorption by the substitution for the exudate of embryonic tissue, which remains and undergoes transformation into adult connective tissue. In this way the fibrinous threads and firmer exudative deposits are converted into permanent connective tissue, the former in the shape of bands that act as checks upon the free movement of the transmitting mechanism. This inflammatory proliferation of tissue is essentially a conservative process, but not infrequently it leads to a hyperplastic proliferation of connective tissue which frustrates its own aim and causes new damage. By the overproduction of embryonic tissue cells and the stimulation of local leucocytosis the inflammatory condition may be prolonged. In the course of time this process may cease and these deposits eventually become absorbed; but some tissues appear to resist the absorption process more vigorously than others, and degenerative changes in the tissue follow. Such changes may be of an atrophic nature, producing abnormal thinning of the structures, or of a chemical character, and result in calcareous degeneration or the deposit of lime

salts in or upon the tissue. Both forms are frequently observed in the altered structure of the tympanic membrane consequent upon an exudative otitis. Anchylosis of the stapes, so common in long-standing cases of chronic middle-ear disease, is often brought about by this form of calcification of the annular ligament which connects the base of the stapes to the oval window; in some cases ossification of the new tissue surrounding the foot plate of the stirrup may occur as the result of inflammatory stimulation.

Symptoms.—The nonsuppurative type of middle-ear inflammations may be ushered in by acute manifestations, but far more frequently its commencement is rather insidious, and, in consequence, the majority of patients suffering with this disease have probably passed beyond the early stages of the affection long before they come under medical observation. So simple and so slow is the onset, and so lacking in the usual subjective evidences of inflammation—pain and fever—that too often the patient is not aware of any serious aural disturbance until the hearing power has been materially decreased. Perhaps the most frequently observed early symptom is the sense of fullness in the ear that accompanies the presence of swelling within the tympanum. Next in importance is the pain, much less severe, as a rule, in the nonsuppurative exudative otitis than in the suppurative exudative form. In a small number of cases the pain is intense, of a sharp, lancinating character, not limited to the ear but radiating over the side of the head. In children, especially those having adenoids, the earache is of short duration, occurs generally at night, and subsides promptly under the influence of heat, but there is a tendency to nightly recur-

rence of what may be termed a subacute form of inflammation. Fever is likewise more commonly noticed among children affected with this disease, and the clinical picture of fever, severe pain in the head, and reflex nervous disturbances may simulate that of acute meningitis. Tinnitus is at times a most troublesome symptom and causes great annoyance to the patient. The degree of deafness present in any case depends mainly upon the extent and location of the inflammatory excretions and the consequent impairment of motion of the transmitting auditory mechanism.

In the long-standing or chronic cases tinnitus and deafness are the only symptoms complained of. The loss of hearing is principally for the lower tones, and does not generally include a marked deficiency at the upper end of the scale, except when the internal ear has become secondarily involved in the process.

Objectively, we are compelled to rely upon otoscopic examination of the membrana tympani for any information as to the nature or extent of the intratympanic disease. If seen in the very acute stage, hyperæmia of the membrane, more intense in the peripheral portions or along the malleus handle, is the most prominent feature. Later, the entire membrane may be congested, or even bulging in some portions from the excessive pressure of exudate in the drum cavity. More frequent than the protrusion, however, is an apparent change in the color of the lower part of the membrane, with a sharp line of demarcation between that and the normally colored upper portion, due to the presence of fluid in the tympanum, the quantity of which is indicated by the height of the line of demarcation. Very soon the external surface of the mem-

brane loses its luster and shows a dull gray or pink-gray color. To separate the simple exudative from the purulent form of inflammation ordinarily occasions no difficulty, except that in the early stages it will sometimes be found hard to predict the ensuance of suppuration. If the amount of exudate be slight, instead of a bulging of some part of the membrane, its retraction will be more or less marked, according to the degree of rarefaction of the atmosphere within the tympanic cavity; and this is evidenced by the concave appearance of the membrane, or by the foreshortening of the malleus handle, and the altered size and location of the light cone.

The chronic nonsuppurative process differs in its otoscopic picture from the acute only in the absence of the principal evidences of active inflammation—redness and swelling, or the presence of a fresh exudation—and the exhibition of the other features in an aggravated form. The degree of retraction, the atrophic thinning or hypertrophic thickening of the membrane, the diminished movement of the malleus under tympanic inflation or otoscopic suction, the adherence of the membrane to the long process of the incus, or of the membrane or malleus to the promontory, all assist in determining the extent of the lesion, but main dependence still has to be placed upon the functional testing of the hearing, in diagnosing the exact situation of the fibrous bands or sclerotic changes which most interfere with audition.

Prognosis.—Uncomplicated acute attacks of nonsuppurative inflammation of the middle ear, dependent upon transitory abnormalities of the nasopharynx, or upon slight pathologic disturbances within the tympanum, frequently terminate in a speedy spontaneous recovery.

When by natural methods alone, or by aiding nature with artificial help, the tympanum can be freed of exudates and the affected tissues restored to a healthy state, the defects of hearing that occur with the more severe cases may be remedied. When the lesions have been such as to leave permanent alterations, decreasing the mobility of the membrane and ossicles, little improvement in hearing can be hoped for, even though the downward process be checked, unless some measures can be adopted to remove the deposits or break up the fibrous adhesions. The severance of these fibrous bands, or the surgical removal of such injurious new tissue as that described, is rendered doubly difficult by the inaccessibility of portions of the tympanum, and by the impossibility of accurately locating and determining their character by the methods of study and observation at present available.

Surgical mobilization of the stapes, incudectomy, and stapedectomy cannot be said to promise as satisfactory results in chronic nonsuppurative disease of the middle ear as when applied to the relief of adhesions or anchylosis occasioned by purulent otitis; nevertheless, these operations have a decidedly important place in the treatment of such conditions, and it is highly probable that better results will follow hereafter, as the indications for their application are made more clear and definite.

The earlier in its course nonsuppurative otitis media is recognized and properly treated the better will be the prognosis in any case; and the more chronic the disease has become before seeking relief at the hands of competent observers, the less is the possibility of retrieving lost ground or the probability of checking the advance of the disease.

Treatment.—In this disease the aurist confronts one of his most troublesome problems. The character of the pathologic changes and the inaccessibility of the parts affected combine to baffle his skill and ingenuity. The reëstablishment of normal intratympanic atmospheric pressure, and the restoration to mobility of the membrana vibrans and the ossicles, are the principal purposes that underlie all efforts at treatment. To accomplish the former, attention must be given primarily to the condition of the nasopharynx and the tympanopharyngeal tube. The removal of any obstruction to the free ingress of air to the tympanum is of the first importance. Nasal spurs, deflections of the septum, hypertrophic enlargements of the turbinate bones, adenoid vegetations, and diseased tonsils demand the most careful consideration and proper treatment. The marked effect of even apparently small digressions in these structures is sometimes surprising. It might almost be said that no abnormality in these regions is too small to deserve attention, in cases where middle-ear disease has begun or is threatening. The grosser lesions, such as adenoids, enlarged tonsils, and hypertrophies of the inferior turbinates, now receive general recognition; but one of the worst offenders against the middle ear is too frequently overlooked. The middle turbinate is only now beginning to be properly studied, and yet it is easily understandable that any obstruction in this part of the nasal chamber is more dangerous to hearing than a greater lesion along the floor of the nose. The inferior turbinal meatus is rather a drainage canal than a part of the respiratory tract. The natural direction of the inspired air is upward and backward through the middle and superior turbinate spaces, and a slight ob-

struction to these channels will produce marked impairment of respiration, with consequent congestion, swelling, and exudation to obstruct the tube or invade the tympanum. Therefore, in searching for nasal abnormalities, particular attention should be given to the middle turbinate bone. It must be constantly remembered that until a fairly normal condition of the nose and nasopharynx has been secured, direct treatment of the ear will be more or less futile.

The nature of the treatment to be employed for this purpose varies with the character of the existing lesion. In the milder cases of exudative nasopharyngitis, acute or chronic, the use of local medicaments by spray, douche, gargle, or direct application by means of a cotton probe, may be beneficial. Anatomical deformities or excessive overgrowth of tissue will usually require surgical intervention for their removal.

Having provided free access for the proper supply of air, the next important step is to make sure that it can enter the tympanum. As has been pointed out in considering the pathology of otitis media, there is almost always an accompanying inflammation of the mucous membrane lining the tympanopharyngeal tube, and contraction of its lumen, varying from a slight reduction in caliber to complete occlusion, may exist. With removal of the source of irritation in the nasopharynx the swelling of the tubal mucous membrane will tend to subside, and obstruction to aëration of the tympanum may spontaneously disappear. The process of restoring patency to the tube may be facilitated, in many cases, by the application of astringents to the inflamed mouth of the tube, and by occasional inflation of the tympanum. Autoinflation, Politzerization,

and catheterization may all be employed under suitable circumstances, but in the majority of instances direct catheterization of the diseased tube is most satisfactory. The careful passage of a silver catheter causes no more discomfort than does Politzerization, and inflation by this means possesses several advantages over the latter. Air is thus introduced into one ear at a time, and with just the amount of force that may be required to produce the desired result. The physician, with the otoscopic tube connecting his own ear with that of the patient, can gather considerable information as to the condition within the tympanum and tympanopharyngeal tube, and can more intelligently determine the character of future treatment; the method is also more cleanly, because there is little danger of forcing secretions from the nose or pharynx into the tympanum, and the catheter should always be sterilized by boiling before introduction. The bulbous-tipped soft silver catheter is preferable, and, if introduced with care, need cause no pain. Spraying the nose and pharynx with cocaine is not, as a rule, necessary. Holding the catheter between the thumb and forefinger of the right hand, it is passed into the nares with the tip directed toward the junction of the floor of the nose with the septum. Keeping the tip pressed gently into this angle, the catheter is inserted until the tip falls over the soft palate; the experienced hand will usually feel this, and, by rotating the catheter outward when this point is reached, the instrument almost invariably enters the mouth of the tube. If in its course the catheter be allowed to rise into the middle meatus, the tip will not rotate into proper position for entering the pharyngeal orifice of the tube. If the entrance of the tip into the pharyngeal space behind the

palate is not distinctly felt, it is a good plan to rotate the catheter toward the opposite side to that which it is desired to inflate, and then withdraw it until its curved portion impinges upon the vomer, from which point a half turn of the catheter outward will cause the tip to present at the tubal mouth. This method seems easier, and gives less discomfort than the plan usually advised, of passing the catheter all the way to the posterior pharyngeal wall and then dragging the tip forward over the post-tubal fossa. The frequency with which inflation should be repeated depends upon the individual case. It should be used sparingly, if at all, in cases where the membrana vibrans is atrophic, or is so relaxed that it bulges under slight pressure. An unduly relaxed membrane is as inefficient for the transmission of sound waves as a retracted one. Where such a condition is found, inflation should be followed by an application of flexible collodion to the distended portion of the membrane.

When the tubal canal is so constricted as to prevent the admission of air, or to permit the passage of only a small amount, and that under strong pressure, some measure of forcible dilatation is permissible. The introduction of plain or of electrolytic bougies through the catheter will sometimes overcome the obstruction, and the effect of direct pressure upon the swollen mucous membrane, or of electrolysis upon fibrous tissue, is said to promote absorption of the hypertrophic tissue and the reëstablishment of a channel. Great care is necessary, however, both in the selection of bougies and in their introduction. The breaking of a bougie in the tube, or puncture of the mucous membrane, with emphysema as a result of subsequent inflation, is little short of a calamity, and force

should never be used to pass a firmly resistant stricture. A few operators have reported satisfactory results from forcible dilatation of the tympanopharyngeal tube, but, considering the general experience of the profession, the method seems justified for use only in exceptional instances.

Efforts at direct medication of the diseased mucous membrane of the tympanum have not given brilliant results. The absorption of exudates and the restoration of healthy tone to the membrane may be promoted by the application, through the catheter, of certain remedies in a gaseous state. The vapors of iodine, chloroform, or menthol may be employed in this way, but the use of solutions of these drugs is not so efficacious, the presence of the fluid seeming to counterbalance the effect of the remedy. The prolonged application of heat would probably be as serviceable here as in similar pathologic conditions elsewhere, but a perfectly satisfactory means of employing it has not been devised.

Much can be done toward securing proper mobility of the membrana vibrans and the auditory ossicles, by repeating the inflations of the tympanum often enough to maintain a just balance between the air pressure upon the two surfaces of the membrane, aided by judiciously moderate pneumatic massage through the external auditory canal. Where the fibrous tissue is still in the formative stage, it is possible that a suction force acting upon the drum membrane may cause a stretching of such fibers and thus diminish their retracting powers, or that by such means the malleus and membrane may be drawn away from the promontory to which they are in imminent dan-

10

ger of adhering. The Delstanche masseur, or the Siegle otoscope with bulb attachment, will furnish all the power that may be judiciously exerted upon the membrane for this purpose. Lucæ's sound applied to the short process of the malleus affords a good means of direct manipulation of the ossicles, and, where there is a tendency to anchylosis of the bony joints, gives satisfactory results.

Organized fibrous bands that bind the membrana vibrans to the inner wall of the tympanum, or hold the ossicles in a false position, can only be reduced by the surgeon's knife. It is sometimes possible to distinguish such synechiæ between the membrane or malleus and the incus, promontory, or stapes, and in such event it is comparatively easy to sever the constricting fibers. Through the opening made by an exploratory tympanotomy other fibrous bands may be found in some cases, particularly those which pass from the incus or from the head of the stapes to the lateral wall of the tympanum, and which seriously embarrass the movements of these bones. Such an opening, furthermore, provides the opportunity for direct mobilization of the stapes, which may be adherent to the rim of the oval window as the result of structural changes in the fibrous tissue surrounding the foot plate. The operations of exploratory tympanotomy, synechotomy, stapes mobilization, and tenotomy of the tensor tympani and stapedius will be described in another chapter. Following all such operations, inflation of the tympanum and massage of the membrane should always be employed and continued for some time, in order that the recurrence of adhesions may be prevented.

SUPPURATIVE INFLAMMATIONS OF THE MIDDLE EAR.—
Aetiology.—Recognizing the important predisposing in-
fluence of acute and chronic inflammations of the naso-
pharynx, and also the generally accepted view of patholo-
gists that there can exist a purulent exudative process
without the presence of pyogenic bacteria, or at least
without its being possible to demonstrate their presence
by any means now known, it is nevertheless necessary to
remember that such microörganisms can be found in the
secretions of the vast majority of all the cases of suppu-
rative otitis media examined, and it would be well, in
consequence of this, to look upon every case of purulent
otitis as bacterial in origin. Repeated attacks of rhinitis,
pharyngitis, or tonsilitis, or the existence of abnormal
tissue developments in the nose or throat, with their
attendant conditions of persistent congestion of the tym-
panopharyngeal tube and tympanum, are favorable to an
infection of the middle ear. Just the conditions most
conducive to the growth and activity of bacteria are ob-
tained in this way: lowered resistance of the tissue cells,
and a serous pabulum in a protected chamber that is
heated to the proper degree of temperature. There lurk
in the throats of all persons one or more varieties of
microörganisms which are capable of doing damage
whenever the other conditions requisite to bacterial in-
fection are provided. One of the organisms most fre-
quently discovered in this inactive state is the diplo-
coccus of pneumonia, and it is worthy of note here that
this particular organism is the one most frequently iso-
lated from the excretions of acute suppurative otitis
media.

The microörganisms that have been found in the pus

from cases of suppurative middle-ear disease, and which have been considered as the cause of the condition, are almost innumerable. Most prominent in a list of such bacteria would be the following: Diplococcus pneumoniæ, Streptococcus pyogenes, Staphylococcus pyogenes (albus and aureus), Bacillus pneumoniæ (Friedländer), Bacillus diphtheriæ, Bacillus tuberculosis, Bacillus influenzæ and pseudoinfluenzæ, Bacillus pyogenes fœtidus and Bacillus coli communis. In acute suppurative cases the pneumococcus is isolated in pure culture much more frequently than any other organism; the streptococcus filling the second place in order of frequency, and the staphylococci the third. In chronic otorrhœa a pure culture of a single organism is seldom obtained; a mixed infection is the rule, and the predominant germ is the staphylococcus. Such organisms as the pneumococcus and the influenza bacillus, which may have occasioned the acute outbreak, soon die out or are displaced by the secondary invasion of more robust microbes.

The exanthematous diseases, especially scarlet fever and measles, are responsible for many cases of purulent otitis, the toxines reaching the middle ear probably by a hematogenous form of infection. In measles the characteristic inflammatory macules have been found on the tympanic mucous membrane coincidently with their appearance in the mouth or nasopharynx, and this could not have been due to extension over the surface from one place to another. In scarlatina, middle-ear complication is much more frequently a sequel to the exanthem, and as it is analogous to the postscarlatinal nephritis, suggests the probability of its having a similar mode of origin.

The entrance of microbes to the middle ear from the external auditory canal may follow solution of continuity of the drum membrane, and bacterial and other irritating substances may be forcibly carried through the tympanopharyngeal tube into the tympanum as a result of violent postnasal douching, Politzerization, or sneezing, and once established there, they may set up purulent inflammation.

Pathology.—The mode of beginning of an inflammation of the tympanic mucous membrane, and the pathologic process to the extent of the formation of an exudate, together with a definition of the several kinds of exudation, has been explained on pages 119 and 120. The primary vascular changes are the same as in the serous exudative process. When, however, pus-producing bacteria are at work, there are especial and characteristic differences in the manufacture of the exudate. Pus cells accumulate in great numbers, and instead of the deposition of fibrin there is a tendency to liquefaction of the exudate and of the necrotic tissue, through the solvent action of the pyogenic germs.

As the result of chemotaxis, the leucocytes leave the blood vessels of the inflamed area to meet the invading bacterial poisons. In the ensuing struggle the leucocyte attempts to engulf and digest the microbe, and restoration to health depends largely upon the ability of the host to furnish a sufficient number of these active guardsmen to overcome the invading pathogenic army. Especially virulent microörganisms, or a too numerous collection of less dangerous ones, may rapidly destroy a mass of white cells, and it is this débris of the battle that constitutes the pus of purulent affections; the tissue cells may also take on the phagocytic action of the leucocytes. Under

the microscope this yellowish-white exudate is seen to
consist of serum, leucocytes, often containing bacteria
within their substance, and the degeneration products of
dead leucocytes and tissue cells.

With the destruction of the epithelium and superficial
portions of the mucous membrane a condition known as
ulceration is produced, and this is probably constantly
associated with suppurative otitis media; the only excep-
tion might be in the few cases of acute inflammation, of
very short duration, where the slight amount of pus that
is formed makes its exit through the tympanopharyngeal
tube, or where the active seat of purulent inflammation
is rapidly transferred from the tympanum to the mastoid
cells without preceding erosion of the tympanic mem-
brane. The extent of the ulcer must vary considerably,
involving in some instances but a small point on the cov-
ering of one of the ossicles or on some part of the lining
of the tympanic walls, in other cases extending over a
comparatively large area of these tissues. Furthermore,
the depth to which this loss of cellular substance or tissue
necrosis extends in the tympanum is a matter for par-
ticular consideration. At no point is the mucous mem-
brane covering the tympanic walls very thick, and over
some portions of the ossicles it is no more than an epi-
thelial coat over a single layer of cells that serves as a
periosteum, with an insignificant amount of fibrous sub-
stance between them. Some of these thinly covered
spaces, particularly on the incus, are also especially prone
to necrosis, because of their poor nutrition under normal
conditions—due to a limited blood supply. When de-
prived of the protection of its periosteal coat, the bone
readily succumbs to the destroyer, and necrosis of the

ossicles is a very common feature of prolonged suppurative tympanic inflammation (Fig. 15).

More frequent still is the ulceration or erosion of the membrana vibrans. This portion of the external wall of the tympanum is the weakest of all and the only one that can give way before the pressure of an accumulating exudate. With the formation of any considerable amount of pus within the tympanum the intratympanic pressure

FIG. 15.—Large perforation with cicatricial remnant of the drum-head anteriorly, the malleus indrawn, the short process alone presenting, the incus wanting, the head of stapes visible and the region of the round window filled with small granulomata.

FIG. 16.—Large inferior perforation and destruction of the pars flaccida, showing head of malleus and articulation with incus.

upon this membrane gradually increases, and as it becomes greater than the external air pressure a bulging outward of some portion of the membrane follows. Diminution of the pressure through the escape of excretions by way of the tympanopharyngeal tube is sometimes possible, but is generally prevented by the blocking of this channel incident to swelling of the lining mucous membrane. Since the attachments of the membrane to the malleus handle and the tympanic ring permit of very little motion outward in these regions, the parts which most readily bulge under pressure are the spaces behind and above the malleus. In consequence of decreased viability of that portion of the membrane subjected to greatest pressure from within, rendering it more liable to ulcerative perforation, spontaneous rupture of the weakened area takes place, and through this perforation the pus exudes into the external auditory canal (Fig. 16).

The time occupied in the spread of an infection from its source to the involvement of the entire middle ear may be very brief in cases of supreme infection. Within a few hours from the appearance of the earliest symptoms the inflammation may travel from the pharyngeal end of the tympanopharyngeal tube to the cellular spaces of the mastoid process. It must be borne in mind, too, that in speaking of the middle ear pathologically, something more than the true tympanic cavity, as described anatomically, is meant. Similarity of structure, of function, and of susceptibility to the spread of disease from one part to another compel the consideration of the tympanum, the epitympanum or attic, the aditus, and the mastoid antrum as one cavity of irregular shape and boundaries. It has been claimed that in every case of suppurative otitis media there is some degree of extension of the inflammation to the antrum. Whether this be true or not—and there would seem to be no good reason for supposing that it is so of the milder acute cases—it does probably apply to a majority of the chronic suppurative cases, and the possibility of its being true of any given case of either the acute or chronic form must be considered.

Could a suppurative inflammation of the middle ear always be confined to the mucous membrane lining the tympanum, or even to the involvement of the ossicles, the disease would have no mortality, and would be of interest prognostically only from the point of estimating the possible impairment of function of the sound-transmitting apparatus of the organ of hearing. Surrounded as the tympanum is, however, by organs and structures more important to life, the problem, when an inflammation breaks through the tympanic bounds, becomes a far more

serious one than that concerned in the effect it may have upon the hearing power. It is by extension from the middle ear that such serious complications as mastoiditis, lateral sinus thrombosis, extradural abscess, meningitis, and cerebral and cerebellar abscesses are produced. In the first named of these the direct route of infection—invasion of contiguous tissue from the tympanum, through the aditus ad antrum, to the cellular spaces of the mastoid process—has already been referred to. When erosion through the roof of the tympanic cavity or of the wall of the lateral sinus occurs, an opportunity is afforded for the direct extension of infection to the cerebral cavity and contents. Indirect infection of the brain or of the sinus is possible only through the medium of the lymphatic or small venous channels.

Regenerative processes are established in the same way and pursue much the same course as those already described in reference to nonsuppurative inflammation. Wherever suppuration has taken place there is a loss of substance, and a more extensive process of repair is required to produce healing and to fill up the wound. The great destruction of tissue in the severe and chronic cases usually implies the impossibility of reparation. Small perforations of the tympanic membrane may become entirely healed; indeed, an entire new membrane may be formed, but such replacement is always by tissue which is histologically different from that destroyed, these new membranes being constructed mainly from outgrowths of the dermoid and mucous coats (Fig. 17). The same proclivity toward the formation of fibrous bands in the cavity, and the anchylosis of the ossicle articulations, exist as in the nonsuppurative exudative processes, at least in the

less destructive cases, and impaired mobility of the sound-transmitting apparatus is not an uncommon result of purulent otitis media. Partially destroyed ossicles are never again made whole, and necrotic spots in the tympanic walls are rarely filled up by new osseous tissue. In the new-formed tissue that closes a perforation of the
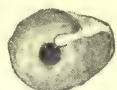
FIG. 17.—Closure of a central perforation by inward growth of cicatrices and dermatization of exposed portion of mucous membrane on inner tympanic wall.
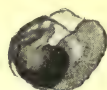
FIG. 18.—Posterior perforation, attachment of malleus tip to inner tympanic wall, incus wanting, cicatricial bands from head of stapes. Anteriorly a small calcareous deposit.

tympanic membrane and in the unabsorbed fibrous deposits on this membrane, calcareous concretions often appear from the deposit therein of lime salts (Fig. 18).

As the result of nature's effort to supply new structures to replace those removed by suppuration, two serious complications of otitis media are possible. Granula-
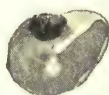
FIG. 19.—Granulomata from a carious incus extruding through a small perforation close to the posterior superior periphery of the drum-head.
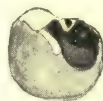
FIG. 20.—Posterior perforation showing descending process of incus and posterior crus of the stapes, with granulomata posteriorly.

tion tissue, springing from some ulcerative point, may readily assume the nature of a polypoid growth, and these polyps, when exuberant, by pressure upon neighboring structures or by favoring the retention of unhealthy excretions, add to the seriousness and chronicity of the original disease (Figs. 19 and 20). The second compli-

cation referred to is the occurrence of cholesteatomatous accumulations. Wandering epithelial cells, or the hyperplasia of cells from the dermal layer of the membrane, at the margin of a perforation, or from ulcerative areas in the lining of the tympanum, lead to the development of cholesteatoma through the excessive growth of these misplaced cells. Occasionally they accrete into a tumorlike mass, producing increased damage by erosion of the surrounding tissue.

Symptoms.—(1) Subjective. From the very beginning of the inflammation until the intratympanic pressure has been relieved by rupture or by incision of the membrane, pain is apt to be constant and severe. In many instances, especially in influenza cases, the pain is excruciating. Earache is ever a pain of peculiar character, comparable only to that arising from injury to or inflammation of the ovary or testicle. It has been shown that stimulation of the sensory nerves of the middle ear, as of those of the organs named, and unlike those of other parts of the body, produces a general vasomotor depression and a reflex cardiac inhibition, which explains the sickening character of the pain and the associated weakness and dispirited condition. Coincident with the disruption of the drum membrane and the outflow of pus into the external canal, pain usually diminishes or entirely ceases. When the pain continues beyond this point it is generally because the break in the membrane has not been sufficiently large to permit free egress to the pent-up excretions, or it is an indication that the inflammation has extended farther than the true tympanic cavity.

Acute suppurative otitis media is almost always accompanied by a febrile condition. In adults the tempera-

ture does not, as a rule, run very high, but in children it is not at all uncommon for the thermometric record to reach 104° F. With the high fever, in very young children, there may be associated nausea, vomiting, muscle twitchings, and convulsions—a clinical picture so closely resembling that of meningitis as to render a serious error in diagnosis possible. The importance of examining the middle ear in every case of obscure febrile disease in infants cannot be too strongly emphasized. In some of these cases there may be a true meningeal inflammation, caused by the extension of the purulent disease from the middle ear; more frequently, however, the symptoms are due to a meningeal irritation only. In early childhood the petrosquamosal suture which crosses the roof of the tympanum has not yet closed by ossification, and other dehiscences in the bone are common, so that where these natural openings occur, the dura lies in contact with the mucous membrane of the middle ear, and is subjected to irritation or inflammation when the latter tissue is diseased.

Functional disturbances are not so marked, or do not attract so much of the patient's attention, as in the nonsuppurative affections. There exists, of course, the same interference with ossicular movements, but the suffering outweighs the loss of hearing. The functional defects that attend the chronic cases, or that remain as a sequel to suppurative otitis media, vary in accordance with the location and extent of tissue altered or destroyed by the disease.

There is one class of cases in which pain and fever may be conspicuous by their absence. Tuberculosis of the middle ear often advances to the stage of a purulent

discharge before the patient is aware of having an aural affection.   The initial stages are not marked by pronounced symptoms, and the progress of the disease is insidious.   Perforation of the membrane occurs as the result of rapid ulceration, not from distension, and as ulcers may have started from more than one point, multiple perforation is not uncommon.   The history of an otorrhœa coming on without antecedent pain should attract attention to the possibility of its tuberculous nature, and there is reason, on the basis of clinical observation, to believe that otitis media may be the primary focus of pulmonary tuberculosis much more frequently than has been generally supposed.

(2) Objective.   In acute suppurative otitis media the appearance of the membrana vibrans is at first exactly the same as that described for myringitis and acute exudative otitis media, and until there is some definite indication that pus is being produced, it is often impossible to make a positive differential diagnosis from the objective symptoms alone.   Given, however, the clinical history showing the mode of onset, amount of pain, existence of febrile temperature, and possible relationship to any other concomitant or precedent disease, a definite conclusion will generally be reached.   After the period of complete congestion of the membrane, the appearance of a yellow or yellowish-red convex area on the drum head indicates the presence of pus and the point where rupture is most liable to occur.   Later, when perforation has taken place, the exact location, size, and shape of the opening can be seen.   Spontaneous rupture may occur in any part of the membrane, most commonly in the posterior segment, and the resulting openings vary greatly in size.   Sometimes

the membrane seems literally to melt away until its destruction is practically complete, with the exception of remnants about the periphery or along the malleus handle. In the cases of the larger perforation the ossicles are frequently exposed to view, and the extent of ulceration or other injury within the tympanum can be studied. If the disease has advanced beyond the tympanic cavity and is invading the mastoid process, firm pressure with the finger directly over the antrum will usually cause pain. This "mastoid tenderness" is one of the most reliable indications of progressive middle-ear suppuration with mastoid cell involvement.

The boundary line between the acute and chronic stage of any disease must of necessity be somewhat arbitrarily settled. Since the latter is but an advanced step in, or the prolonged existence of, the former, and the pathologic changes exhibited have merged gradually the one into the other in the evolution of the disease, there will often be room for honest differences of opinion as to the moment when one ceases and the other begins. The clinical picture of chronic purulent otitis differs from that of the acute in the length of time it has existed and in the extent of its lesions.

Diagnosis.—Little or no difficulty is experienced in determining the seat and nature of this disease. The impossibility of saying, during the initial stages, what the exact future of a commencing middle-ear inflammation will be has already been alluded to. Pain in the ear generally means either an otitis media, otitis externa, or a reflex symptom, and inspection promptly settles any doubt as to which is the cause. The only point to which it is appropriate to call attention here is the necessity for

great care, not in diagnosing the disease, but in accurately ascertaining the site, character, and extent of the lesion or lesions. In order to secure the greatest success in treatment, the earliest stoppage of an existent suppurative process, prompt repair of the injured tissues, removal of the detrimental remains, and restoration of the greatest amount of functional ability, it is essential to possess a full knowledge of these points.

Prognosis.—During recent years the prognosis of suppurative middle-ear disease, including all of its complications and eventuations, has very materially improved. A better realization of the importance of the disease has led to its earlier and more persistent treatment, and antiseptic surgery has enabled the aurist to save the lives of many persons whose condition would, a few years since, have been looked upon as hopeless. Of perhaps more importance is the fact that surgical improvements have put it in the power of the aurist to prevent many of the serious complications of this disease.

By proper local medicinal measures a majority of all cases of acute suppurative middle-ear disease can be easily and speedily remedied. By such treatment is meant the procuring of free drainage from the tympanum of all excretions, and the maintenance of as perfect cleanliness of that cavity as is possible. Some cases appear to be, in the very nature of things, destined to pursue a chronic course, and others enter upon chronicity because of the greater activity of the destroying agent or the greater difficulties in the way of getting rid of the débris, and the subsequent institution of a reparative process. In a fair proportion of such cases general tonic and hygienic treatment, added to the local antisepsis, promotes a favor-

able result, and nowhere in medicine will well-directed, patient, and persevering efforts be more surely rewarded.

Of the chronic cases—taking them as they come, and including cases of many years' standing—fully one half will recover under simple drainage and antiseptic treatment. The others will require some surgical assistance through the medium of the external canal, the removal of polypoid tissue, of necrotic ossicles, or cholesteatomatous accumulations. Only the great minority demand the application of more extensive surgical intervention. To these, tympanomastoid exenteration is applicable, and the results obtained are satisfactory. Not all cases are cured by this last resort, but the great majority are, and only an insignificant percentage of the whole number of otorrhœas is left unhealed. That this small proportion will steadily decrease in the future, as the technique of the graver operation improves in the hands of the mass of operators, is to be expected.

Treatment.—From the moment when it becomes certain that a purulent inflammation is established within the tympanum, and thence throughout the whole course of the disease, the guiding principle of treatment consists in providing a free course of egress for the excretions, and of efforts to render the tympanic cells and their contents sterile. In the very earliest stage of otitis media attempts may be made to abort suppuration. Chief among these abortive measures is local vascular depletion. The application of anodyne mixtures to the external surface of the tympanic membrane, and the local use of heat in the form of hot irrigations, or of dry heat conducted through the external auditory canal from a Japanese hot box or a heated cloth held over the auricle, may assist

materially in reducing pain and favoring resorption of fresh exudates. But free bloodletting often accomplishes this, and something more. In addition to the directly good results of diminution of tissue engorgement by the withdrawal of blood, the vasomotor changes effected by leeching institute a revulsive or counter-irritant action which is distinctly beneficial. The most effective points for leeching to reduce middle-ear congestion are over the mastoid antrum and near the tip of the mastoid process. Before applying the leech, the skin should be carefully cleansed, as in preparation for any other operation, and the artificial is preferred to the natural leech for obvious reasons. From 30 to 100 c.c. of blood may be withdrawn, according to the anæmic or plethoric condition of the individual. Aside from such local measures, and the administration, when necessary, of morphine for the relief of pain, a further detergent influence may be produced by the use of calomel to the point of producing free purgation.

When the inflammatory process proves resistant to such treatment, and the evidences of pus formation become pronounced, or when the exudative collection is excessive, even though the change to purulency is not actually demonstrable, surgical intervention for the relief of discomfort, the evacuation of the cavity, and the prevention of greater disaster is advisable. Paracentesis is certainly justifiable whenever there is a definite outward bulging of the membrane, without waiting for the yellowish discoloration indicative of the presence of pus. In very many instances it can be wisely employed, even in the entire absence of bulging. The good surgical rule, to cut for a cure of acute cellulitis before pus has formed, is

11

applicable here, and the benefits derived from an early paracentesis far outweigh any possible evil effects which can result from its too hasty performance.[1] Supposing no pus flows at once from the incision, still the depletion, by hemorrhage, of the hyperæmic tissue reduces tension, alleviates pain, permits evacuation of the simple exudate, and checks the inflammation. It is true that an opening in the drum membrane provides a gate of entry for micro-organisms coming through the external canal, but it is more than probable that the tympanum is already infected, and very improbable that further infection will take place if proper aseptic precautions have preceded paracentesis and post-operative cleanliness of the canal is maintained. A clean incision of the membrana vibrans, properly located, is not a matter of grave importance, for if the inflammation proves to have been nonpyogenic, it promptly heals, and function is in no practical sense impaired.

If pus is present, its immediate removal, followed by cleansing of the tympanum, permits a rapid restoration of health to the tympanic mucous membrane and a re-union of the wound margins. If paracentesis be unduly delayed and pus formation continues, spontaneous perforation results from ulceration of the membrane from within outward; excessive intratympanic pressure possibly assists this process. Perforation occurs near the center of an ulcerating area, and is, naturally, surrounded by an areola of weakened tissue, some of which will be likely to slough away and further enlarge the opening. Repair of perforations produced in this way is slow and uncertain; very frequently nature fails to reproduce sufficient new tissue to cover the defects.

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[1] See Appendix, note 1.

With the rupture of the membrana tympani, whether by natural or artificial means, and the establishment of a purulent flow into the external auditory canal, the second stage of treatment for purulent otitis media is entered upon.   Here the indications are for a complete cleansing and sterilization of the tympanum.   Unless the opening in the membrane is sufficient to permit free drainage from the middle-ear cavity, it should be enlarged so that the lower end of the incision terminates at the lowest peripheral point.   Effort must then be made to remove the excretion from the tympanum as rapidly as it is manufactured.   Two methods of attaining this end are available; each has its partisan advocates, and either is efficient if conscientiously followed.   The so-called dry treatment consists in securing constant drainage by the aid of a wick of gauze, the inner end of which is carried to or through the perforation.   A change of wicks should be made whenever the one in place gets saturated, and any accumulation of pus in the cavity or canal is thus prevented.   Adherents of this method profess to consider with serious apprehension any thought of irrigating the canal or tympanum, basing their disapproval upon the fear that septic particles might be forced into the mastoid cells.   The fact that the antrum is supposed to be always involved in such inflammations of the middle ear does not, of course, warrant one in taking uncalled-for chances of adding to the antral infection, but the infrequency with which mastoid empyema occurs during an acute suppurative otitis media while under treatment by a method so universally used as is irrigation, argues strongly against any calculable probability of danger from this source.

The second plan alluded to consists in frequent flush-

ing of the canal and tympanum with a sterile or antiseptic fluid introduced through the external auditory canal. Any aural syringe, or the usual irrigating bottle or bag, with a suitable nozzle, may be used for the purpose; at least 500 c.c. of fluid should be used at each syringing, and the process should be repeated as often as may be necessary to keep the parts freed from purulent collections. In acute cases very good results can be obtained by the use of plain sterile water only, but properly prepared solutions of antiseptics can do no harm, and give an additional sense of security, especially when dealing with the more virulent organisms. More important than its chemical constituency is the use of a quantity of the fluid sufficient to insure a thorough washing away of all the pus.

The weakness of the dry method lies in the fact that the wicks must be frequently changed, and that their introduction requires a skilled hand. Only in hospital work, or under exceptional circumstances in private practice, can the surgeon see his patient often enough to make sure that he is succeeding in his object of keeping the ear clean. Most patients will misunderstand the request for or will refuse to make numerous visits to the aurist; the substitution of clean wicks for the moistened ones cannot be trusted to the untrained, and the plan which has been suggested, of placing a small permanent wick in the inner end of the canal and absorbing the discharge from that by cotton or gauze pledgets inserted in the meatus, and frequently changed by the attendant or patient, is not reliable. For the great majority of patients suffering from otorrhœa, continued personal attention from the physician is impossible, and the endeavor to bring about

the desired result must be left to some friend or relative, or, at best, a nurse. The least intelligent of these can be taught, without much trouble, to use the aural syringe with a fair degree of efficiency. Most persons require some instruction regarding manipulation of the auricle and the distance to which they should insert the syringe tip before they can be expected to properly cleanse even the canal, and all should be advised to continue the washing until there is no reasonable doubt of having removed all of the excretion. It is impossible to say that any given volume of fluid will accomplish this in all cases; the expert may succeed in one case with, perhaps, 50 c.c., and yet, owing to a tortuous canal or a stringy, ropy, or adhesive exudate, in another case find 1,000 c.c. none too much. How futile, then, are apt to be the directions to an unskilled nurse to use a teacupful or a tumbler of the antisepticized water. If directed to use not less than half a liter, and preferably more, at each sitting, the likelihood of securing satisfactory results is greatly enhanced. Irrigation should be followed immediately by a careful drying of the canal, and this can be attained fairly well by repeated insertion of wicks of absorbent cotton.

In chronic suppurative otitis media the use of antiseptics in the irrigation is an essential part of the treatment. As has been explained in discussing the pathology, the problem here is not simply one of drainage, but of sterilizing the contents of the tympanum. If a purulent residuum cannot be drained off, it must be rendered innocuous, and this may be accomplished by the mixing with it of the antiseptic during irrigation. One of the most efficient of the germ-destroying drugs employed for this purpose is formaldehyde. A solution of this gas,

known commercially as formalin, may be prescribed in the strength of from 4 c.c. to 8 c.c. to the liter of boiled water. As formalin is a forty-per-cent solution of the gas, this makes an irrigating fluid containing the gas in the proportions of from 1–600 to 1–300. Various other germicides may be used in the same way, and very good results accrue, in some cases, from following the removal of accumulated excretions by the introduction of small amounts of stronger germicides, or of astringents, directly into the tympanum. Solutions of silver nitrate, protargol, or argyrol are recommended for such use, applied by means of the cotton-tipped probe.

The middle-ear syringe is a valuable instrument in cases where the purulent collection is inaccessible to fluids introduced indirectly from the external canal. The tip of this little instrument can be carried into the tympanic
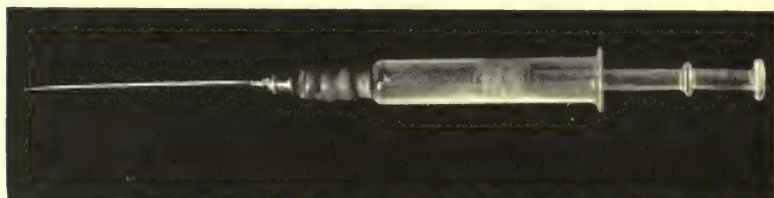
Fig. 21.—Middle ear syringe.

cavity, and the antiseptic stream brought more directly in contact with the diseased tissues. The intratympanic syringes are of various forms, from a simple metal cannula to a piston syringe with cannula attached. A glass syringe of the latter sort, with asbestos packing, is easily sterilized, and is preferable to a syringe of metal or hard rubber (Fig. 21).

Hot air and medicated vapors have only a limited field of usefulness in this affection. Antiseptic and drying

powders are valuable adjuncts to the treatment in some instances, but they should be reserved for the period when the discharge is on the wane, and then used with such care as to avoid the possibility of hindrance to its exit. They must never be packed into the canal, nor allowed to obstruct a small perforation, lest retention of purulent matter result.

Having patiently, persistently, and perseveringly tried all simple means to overcome an otorrhœa, without success, the existence of a deeper focus of suppuration, in a bone necrosis, is presumable. It is not often possible to see the carious spot, nor can any conclusive evidence be deduced from the odor or appearance of the discharged pus. There is a peculiarly fetid odor associated with decaying bone, but it cannot be depended upon as an infallible guide in determining the existence or extent of bone disease in suppurative otitis. Microscopic examination of the discharge may show bone dust; in that event the diagnosis of caries is positive. The presence of polypoid masses or redundant granulomata are suggestive of bone caries. They should be removed by means of the snare or curette, and the subjacent surface carefully examined.

Otorrhœa, uncontrollable by the line of treatment suggested, almost always indicates ossicular ulceration or extension of the suppuration to the cellular structures of the mastoid. Ossiculectomy is appropriate to the first class of cases, tympanomastoid exenteration to the second. Neither of these operations is to be undertaken lightly, and an honest effort to procure healing by simpler measures should precede consideration of surgical attention. Indefinite prolongation of such treatment, however, is not justifiable, and the fact that serious complications

have not supervened does not excuse interminable delay. Many apparently hopeless otorrhœas have been cured by persistent, painstaking, simple medicinal treatment; but far too many neglected cases have terminated fatally, when a timely ossiculectomy or mastoid operation might have prevented such a catastrophe. The complete operation of tympanomastoid exenteration may be held in reserve for cases which ossiculectomy has failed to relieve, or for use in cases where evidences of mastoid involvement are comparatively clear; but no patient who is the subject of a purulent discharge from the middle ear should be permitted to look upon his condition as one without danger to life, and conservatism demands surgical intervention, rather than abstention therefrom, in every case of chronic suppurative otitis media in which other kinds of treatment have failed of effect.

CHAPTER V

THE POSSIBLE COMPLICATIONS AND CONSEQUENCES OF SUPPURATIVE OTITIS MEDIA

A PURULENT inflammation of the middle ear may persist for many years without causing serious disturbance of health or destruction of any tissue beyond the confines of the tympanic cavity. On the other hand, it is becoming generally recognized now that the mere existence of such a purulent focus is a constant menace to the health and life of the individual bearing it, and that at any moment it may flare up into an active process which will be extremely difficult to check or control. A victim of chronic otorrhœa is constantly contributing something from his tissues to gratify the insatiable appetites of unwelcome guests, the pyogenic microörganisms; his system is being steadily drained of some elements which might be far better utilized, and he must be constantly losing some degree of vitality. In addition to this fixed charge against his resources, he carries an undeterminable yet certain risk of secondary personal infection and an incubator for bacteria to supply contamination to his neighbors. The importance of these aspects of the problem is only beginning to be recognized. The important observations and investigations of Ponfick and of Meltzer illustrate how frequently serious and even fatal inflammatory affections

of the throat, lungs, and intestinal tract may be traced to a primary focus in the middle ear. It is shown to be true, particularly in children, that death may ensue from one of these more general systemic affections without the preëxisting acute otitis media having been suspected. How often may the pharyngeal, bronchial, pulmonary, and enteric inflammations, which occur in persons having a chronic otorrhœa, be due to purulent secretions from the tympanic cavity, reaching the respiratory or intestinal tracts through the tympanopharyngeal tube? Even less appreciated, as yet, are the dangers entailed upon the community by such a source of contamination. Pus from any other part of the body is shunned as a known dangerous element. The purulent outflow from the ear, though produced by the same microörganisms, is too often looked upon by patients and their relatives as a discharge of innocent character. A fruitful field of investigation might be opened up if the effort were made to ascertain how often the pneumonias and streptococcic sore throats of school children, for instance, could be traced to direct or indirect infection from schoolmates suffering from purulent otitis.

But more important than these indefinite risks and dangers, and certainly more susceptible of positive demonstration, may be considered the grave complications and consequences which accompany the direct extension of suppuration from the tympanum to neighboring vital structures. Considering the close proximity of the brain, the jugular vein and lateral sinus, and some of the cranial nerves, to the middle ear, and the frequency with which this cavity is the seat of acute inflammation, it is rather more surprising that they are so seldom invaded, than

that they should be occasionally involved in an extension of the disease. When suppurative otitis media has once started on a destructive tour, it may invade the mastoid portion of the temporal bone, the soft tissues of the neck, or the cranial cavity. While the source and route of invasion are the same in nearly all cases, and the diagnostic name applied to any given case is chosen with reference mainly to the extent and location of the lesion, it will be necessary to make some degree of repetition by considering these lesions separately, on account of their varying symptoms and surgical indications. The sequels to purulent otitis media will therefore be considered as: 1, Mastoiditis; 2, Lateral Sinus Thrombosis; 3, Labyrinthine Suppuration; 4, Cerebral and Cerebellar Abscesses and Meningitis.

1. MASTOIDITIS

Aetiology.—The frequency with which inflammation of the mastoid portion of the temporal bone is encountered depends upon several circumstances. The first of these to demand attention is the effect of climate. In those parts of the world where persons are exposed to extreme degrees of cold, and to sudden and violent changes in weather conditions, it is but natural that those who are compelled to live much in the open air should be more frequently subjected to inflammation of the middle ear and its adjacent mucous-membrane-lined cavities than is the case with those who enjoy living within more salubrious surroundings. Low degrees of temperature, associated with excessive amounts of moisture in the atmosphere, are especially prone to irritate the nasopharyngeal and aural mucous membranes. The influence of cold alone

probably cannot induce a destructive purulent inflammation, but it may render the tissues more susceptible to the ravishing onslaught of the pyogenic microörganisms, and enable the latter to make more rapid progress; hence the more common occurrence under such conditions of mastoiditis in the course of acute otitis media.

The next most important factor is the frequency in some districts of epidemics of certain diseases. Thus, epidemic influenza may recur at short intervals in some communities, and some of these outbreaks are followed by unusually high percentages of middle-ear involvement with complications. Scarlatina, measles, diphtheria, typhoid fever, tuberculosis, syphilis, and other systemic diseases, may be associated with a primary attack of purulent otitis and mastoiditis, or may provoke an old chronic middle-ear suppuration to renewed activity, and produce the conditions favorable to involvement of the mastoid cells.

Finally, the anatomic character of the temporal bone may be considered as a predisposing factor; pneumatic bones whose cells communicate freely with one another and with the antrum being more easily invaded than diploetic or eburnated specimens.

Primary inflammation of the mastoid cells must be exceedingly rare. That such a condition may occur is of course possible, but its happening has been so infrequent as to make the reports of such cases worthy of note. The secondary infection of this region by the transmission, from some more or less distant point, of septic material through the vascular or lymphatic channels, must likewise be an uncommon affair. The usual method of invasion of the mastoid process is by direct extension thereto of

inflammation from a neighboring diseased tissue. This may be from advancement of an otitis externa through the posterior wall of the external auditory canal, or from perforation of the external cortical surface of the process by a mastoid periostitis, but in the vast majority of instances it is due to the spreading of a suppurative process in the tympanum, through the aditus ad antrum, into the antral and other cells of the mastoid. The active agent in such a progressive inflammation is some virulent pyogenic bacterium, and the contributory conditions are favorable anatomic structure and lowered local resistance. Most prominent among the bacteria causing inflammations of the mastoid cells are the Streptococcus pyogenes, Staphylococcus pyogenes albus and aureus, and the Pneumococcus, but a great variety of other organisms are included in the list of those occasionally found.

Pathology.—In what proportion of cases the secretions from an acute suppurative otitis media actually enter the antrum has long been a matter for speculation. Some eminent authorities believe that such invasion is invariable. That the opportunity for inflammatory trespass is always present may be granted, but there are also certain safeguards against it to be considered. The canal connecting the tympanum and antrum is not always a large and widely open one, but very frequently small in diameter, and at times even of minute size. Furthermore, the inflammatory swelling of the tympanic mucous membrane, in advanced acute cases, tends of itself to diminish the caliber of this channel, and when the opening is but small, complete occlusion may occur and thus prevent the overflow into the antrum. This occlusion may, however, work in a disastrous way by penning up

pus which has reached the antrum before closure of the passageway took place.

The canaliculi uniting the antral space with the other cells of the mastoid bone are usually very small, and if it be true that the antrum is so frequently concerned in the inflammatory affections of the tympanum, the swelling which accompanies inflammation of the lining tissue of this cavity must generally serve to wall off the abscess and limit its progress. Under such circumstances, any excretions that may be produced find their exit into the tympanic cavity by the existing channel, after the swollen condition of the tissues has subsided, or become an isolated focus of suppuration. The pathologic process then is not different from that occurring under similar circumstances in any other part of the body. When the mucous membrane becomes inflamed, the underlying bone is very apt to be affected, and to participate in the degeneration if the irritation persists. The speed with which an inflammation advances here depends upon the virulency of the invading organism, and the density as well as the resisting power of the bony structure. By a process of molecular disintegration or ulceration, the abscess cavity grows as the necrosis advances. Naturally, the more dense the bone, the slower will the pernicious change proceed; the more cellular its composition and the larger the vacuoles, the more rapid and extensive will be the destruction. The normal histologic structure of the mastoid portion of the temporal bone is subject to wide variations, the antrum mastoideum and the apical cell near the tip of the process being the only fairly constant cellular spaces existing therein. The location of other pneumatic areas may play an important part in determining the course

which a destructive suppuration shall pursue. Thus, in a purely pneumatic type of mastoid the entire internal framework may be rapidly broken down and the cortex perforated. In the diploetic or the partially eburnated form, the necrosis, advancing in the direction of least resistance, may descend toward the apex of the mastoid, ascend toward the cerebral cavity, or proceed anteriorly, posteriorly, internally, or externally, toward the digastric fossa, the lateral sinus, the internal ear, or the outer surface, respectively, according to the resistance encountered. When an active inflammation has once become established in the mastoid bone, even when limited to the antrum, the escape of its products through the tympanum and external auditory canal is difficult, the floor of the antral cell being decidedly lower than the antrotympanal canal, and the retention of the deleterious substance is favored by physical conditions. Extension through the canaliculi connecting the numerous cells explains the progress of the disease in many instances. The Haversian canals also afford a ready means for the spread of bone inflammation, and the perivascular spaces constitute a third route for infective travel.

Fortunately, not every case of mastoiditis goes on to complete destruction of the mastoid process or to invasion of surrounding structures. In many instances the antrum alone is involved, or only a limited area of bone disintegrates, and the purulent mass is discharged through the tympanum and external auditory canal. Occasionally the necrosis may cause segmentation of a small area of bone and the formation of a sequestrum. When the inflammation is checked in its incipiency, or is of the milder type, nature endeavors to remove the irritant through increased

vascularization, and to repair any injury by new tissue production. As a consequence of excessive bone-cell proliferation the whole mastoid process may be converted into a compact bony mass with little trace of a cellular structure.

The portions of the mastoid bone which appear to be most frequently concerned in circumscribed abscess formation are, in the order named, those involving the group of cells immediately below and in front of the antrum, including that wedge-shaped area between the antrum, tympanum, and external canal; the cell or cells situated in the tip of the process; the vertical line of cells along the posterior border of the process, encroaching upon the sigmoid sinus groove; and the supra-antral cells located in the tegmen mastoideum.

Symptoms.—Mastoiditis, especially in its early stages, is characterized by but few symptoms. The important ones are pain, localized tenderness, swelling, and fever.

Pain is the most prominent and most constant symptom either in the acute or chronic form of the disease, and is generally assigned to the region just behind the auricle, but may be diffused over the entire side of the head. It varies greatly in intensity, some patients seeming to suffer excruciatingly, while others scarcely complain at all. Its presence or absence is of little diagnostic value, except in so far as its existence may serve to call attention to the ear as the possible source of trouble. In a large number of cases there would appear to be some definite relationship between the degree of pain suffered and the amount of otorrhœa, yet such a law has not been certainly established. When the outflow from the tympanum is free and

profuse, pain is not likely to be severe. On the other hand, those cases of mastoid inflammation whose commencement is coincident with a diminution or cessation of the tympanic discharge are usually marked by sharp pain.

More important than the subjective pain complained of is the localized tenderness which may be elicited by slight pressure over the affected area. This is unquestionably the symptom of greatest diagnostic value in this disease; it is almost invariably present, and constitutes the best guide in the treatment to be employed. Some care must be exercised in trying to ascertain the existence and degree of tenderness. Pressure should be exerted directly upon the surface of the mastoid in such manner as to avoid touching the auricle or disturbing the posterior cartilaginous wall of the external auditory canal. Diffuse or circumscribed otitis externa might give an apparent tenderness of the mastoid region if the pressure were so awkwardly applied as to move the auricular cartilage. Of course, inspection of the canal would still be a means of preventing error in diagnosis. If pyæmia of the mastoid cells exists, some degree of tenderness may nearly always be elicited by firm pressure over the antrum or between that spot and the tip of the mastoid process. The amount of tenderness shown does not necessarily indicate a relative measure of suppuration or necrosis within the bone, nor does it enable the observer to bound the district of tissue invaded. The principal point of tenderness is the site of the antrum, and yet, with tenderness limited to that region, operation may disclose the main collection of pus in some other part of the bone. Pain on pressure over the tip cannot be taken to mean always that the tip cells are engaged in the suppuration, though it

12

frequently has such significance, but tenderness along the posterior vertical border of the process, and especially along the course of the mastoid emissary vein, is strongly suspicious of invasion of the sigmoid sinus groove, and possibly of thrombosis of that vessel.

The estimation of mastoid tenderness is far from being an accurate procedure. In addition to the different degrees of susceptibility to pain displayed by patients, there is no standard for the amount of pressure employed by different examiners other than is expressed by the words gentle, firm, and deep. What one person would consider a very gentle application of force might represent to another a firm, heavy effort. Such discrepancies may be prevented by the use of an instrument which will register the amount of force required to elicit the first sign of discomfort, empower the watcher to note the effect of increasing pressure, and permit the study of smaller points on the surface of the bone than can be palpated by the finger alone.[1]

Swelling of the soft tissues over the mastoid is not usually present until the abscess has broken through the external cortex of the bone, and caused a mastoid periostitis or a subperiosteal collection of pus. Œdema of this region does occur occasionally, but it is more frequently associated with inflammations of the cartilage of the auricle and canal wall. With a subperiosteal collection of pus over the mastoid bone there is redness of the skin, and, as the exudate increases in amount, a characteristic forcing forward of the auricle, so that it stands out nearly at right angles to the head. Of vastly more

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[1] An instrument designed for this purpose is described in the Appendix, Note 3.

importance, as a symptom of suppuration within the mastoid, is the swelling of the inner end of the posterior canal wall. Redness of the cutaneous lining of the external meatus, with a bulging or drooping of the postero-superior wall, is a nearly infallible sign of mastoiditis, involving the antrum and neighboring cells. In some cases the bulging may be so great as to prevent otoscopic inspection of the membrana tympani. Touching the swollen district with a cotton-tipped probe elicits marked tenderness. (See Appendix, Note 2.)

Swelling of the cervical lymph glands is a significant symptom, and often of great diagnostic value. In chronic middle-ear suppurations the swelling of these glands may be expected. It is not the rule in acute cases, but when the mastoid is also affected painfully swollen glands beneath the mastoid and over the place of origin of the sterno-cleido-mastoid may generally be found. Such glandular swellings are of special diagnostic value in cases of suspected mastoiditis in young children, where, when associated with an acute middle-ear suppuration and an otherwise obscure febrile condition, their finding may be of great practical assistance in determining the necessity for operative intervention.

Acute inflammation of the mastoid cells is always accompanied by some elevation of temperature, but the degree of fever has no direct relationship to the severity of the inflammatory process. As a rule, the temperature ranges higher in children than in adults, not infrequently reaching a height of 105° F. in the former, whereas in the latter anything above 102° F. is exceptional in uncomplicated mastoiditis. Chronic inflammation of the cells, spreading in a slow and insidious manner from a long-

standing chronic suppurative otitis media, may run a course so nearly afebrile that the rise of temperature is unnoticed until some vital structure is attacked or septic absorption produces a sudden and pronounced fever.

Since the majority of cases of mastoiditis are preceded by purulent middle-ear disease, otorrhœa is a common symptom. It is absent only in the rare cases of primary mastoiditis, in those cases secondary to otitis, but in which the tympanic membrane has not ruptured either because of rapid advance of the disease through the tympanum into the antrum, or because of the subsidence of the middle-ear affection and the steady progress or exacerbation of the mastoid affection, and those instances of chronic suppurative otitis media in which sudden suppression of the discharge is coincident with the onset of acute trouble in the mastoid. The history of an existing or precedent otorrhœa should always be taken into account when considering the origin of any febrile condition, and particularly is this true of the obscure fevers of young children.

Diagnosis.—The clinical picture of mastoiditis is usually a very distinct one, and the cardinal features have been outlined in the preceding paragraphs, the signs being considered in the order of their importance from a diagnostic standpoint. In many instances all of these evidences are presented so clearly as to point unmistakably to empyema of the mastoid cells. In other cases one or more of the symptoms may be entirely missing, or present in a modified form, and then the true image of the disease is blurred. Thus, the element of pain may be lacking, the fever of very low grade, or the discharge suppressed. The entire absence of localized pain is so rare as to make

the number of cases of painless mastoiditis a negligible quantity. Tenderness on pressure over the antrum or near the tip of the process can be elicited in nearly every case. Its location and intensity have some, at present indefinite, relationship to the extent of the necrosis. The nature of the meatal discharge may help materially in determining whether the mastoid cells are involved, and whether the inflammation is likely to be a mild or severe one. The outflow of pus may be so profuse as to force the conclusion that a larger area of tissue than that inclosed within the boundaries of the tympanum is necessarily concerned in its formation. If the perforation of the tympanic membrane be of sufficient size and in a favorable location, it may be possible to see the pus running into the tympanum from the antrum. On such occasions it will be observed that after a careful cleansing of the tympanic cavity pus speedily reappears, and that it is flowing in a line over the inner wall from the postero-superior to the postero-inferior quadrant.

Microscopic examination of the excretion assists only in so far as it discloses the microörganism which is at work, or shows the presence of bone débris. The latter may, of course, be due to caries of the tympanic walls or of the ossicles, and consequently is of little diagnostic value. Any of the pathogenic bacteria may, under favorable circumstances, assume virulent properties, but of those ordinarily isolated from aural discharges the streptococcus is viewed with more alarm than the staphylococcus or the pneumococcus, because of the seemingly greater probability of its causing widespread destruction of tissue and a rapid advance to a general septic condition. The finding of it in the middle-ear discharge not only enhances the

gravity of the otitis, but should put one on guard against the possibility of extension of that disease; and another symptom which sounds a warning to the cautious observer is the persistence of pain in the ear after rupture of the membrane has occurred and a free drainage of the tympanum is established.

Neglect of mastoiditis in its early stages is very common, but confusion of it with other affections, except in children, is rather unusual. Differential diagnosis, therefore, is seldom called for. Furunculosis of the external auditory canal wall and diffuse otitis externa may be associated with otorrhœa, pain and tenderness behind the ear. Mastoid tenderness is elicited in the above-named conditions only when the test is so carelessly applied that the pressure is at the same time exerted upon the cartilage of the auricle, and otoscopic inspection of the canal will remove any doubt as to the source of pain and discharge.

One of the conditions consequent upon mastoiditis, which may cause some confusion by masking the bone disease, is the development of an abscess in the digastric fossa—the so-called Bezold abscess. When the necrotic inflammation of the cells has eaten its way through the anterior surface of the process, and tension is relieved by escape of the purulent exudate into the soft tissues of the neck, mastoid pain and tenderness may subside almost to the point of cessation. As the pus accumulates under the anterior border of the sterno-cleido-mastoid muscle and the resistance to the abscess growth increases, these symptoms generally recur and may be intensified. A circumscribed swelling in that part of the neck is suggestive of mastoid disease, and a review of the patient's recent

history will promptly determine whether there exists such a connection.

Failure to recognize mastoiditis promptly, or the undue delay of a mastoidectomy, may sometimes result from mistaking the clinical symptoms exhibited for those of one of the infectious diseases like typhoid fever, malaria, or influenza, or from attributing too much importance to the possible connection between the mastoid symptoms and a coincident attack of one of these affections. It has not infrequently happened that an acute mastoiditis associated with chronic suppurative disease of the middle ear has been attended by a febrile condition closely resembling typhoid; in such cases the temperature chart may show an almost typical typhoid curve, and if the aural pain is not severe the ear may be entirely overlooked. On the other hand, when the mastoid condition is properly understood, a question may arise as to whether there may not be a coexistent typhoidal infection. Confusion regarding malaria does not occur so frequently, but is apt to be quite as serious a matter for the symptom which suggests that diagnosis, a chill, or series of chills, may be an indication of grave systemic infection by the extension of a suppurative process to the lateral sinus or the brain. Mastoiditis occurs quite commonly as a sequel to or complication of influenza, and the effects of the latter are of such a varying character that it may be very difficult at times to determine what part of the patient's condition is attributable to the general and what part to the local affection.

Fortunately, a ready and accurate means of clearing up the diagnosis in all these cases is available. A simple blood count to ascertain the number of leucocytes present

will determine the existence or nonexistence of a purulent process. That a pathologic leucocytosis indicates abscess formation is as true in aural as in general surgery. It is now a well-recognized fact that in all three of the diseases named, typhoid fever, malaria, and influenza, the number of leucocytes is, as a rule, lower than normal. Consequently it is not necessary to await the agglutination test for typhoid, or the search for malarial parasites in the red blood cells, if a count of the white cells shows a leucocytosis. The value of the assistance to be gained from a leucocyte count in doubtful cases cannot be overestimated, for it must not be forgotten that indecision regarding operation, in some instances, may be fraught with the most deplorable consequences to the patient.

Prognosis.—Acute inflammation of the mastoid cells occurring as a sequel to acute suppurative otitis media has a favorable prognosis. The treatment to be employed, as well as the gravity of the affection, depends upon the stage to which the disease has progressed—that is, whether it is simply in a state of congestion, or has reached the condition of empyema. If it can be determined that pus is present in the cells, the prognosis can be kept favorable only by the prompt institution of measures for its evacuation. On the other hand, if it is not clear that pus has formed, tentative measures may be employed with a reasonable hope of aborting the process. In a series of fifty consecutive cases entering the Massachusetts Eye and Ear Infirmary with evidences of mastoid inflammation, but without the indications for immediate operation, palliative treatment consisting of rest in bed, continuous use of the Leiter coil, and free opening of the tympanic membrane to permit drainage and cleansing, was conducted

under the observation of Dr. Philip Hammond, with the result that thirty cases recovered with disappearance of the mastoid symptoms; seventeen came to operation within a few days; three patients, who were discharged as apparently relieved, subsequently returned for operation. This would seem to be a fair statement of the chances of recovery in this class of cases, as it accords with the experience of many good otologists, several of whom are on record as having said, without an attempt at exact statistics, that approximately three fourths of such cases get well without an operation. It must not be forgotten, however, that this class comprises only a portion of all the cases of mastoiditis. During the same period of time in which these fifty patients were received at the hospital a considerable number were admitted with symptoms of such advanced mastoid disease that immediate surgical intervention was demanded. So, while sixty per cent of the first type recovered without operation, the percentage of the whole number to so recover was much smaller.

The prognosis of the empyema cases is also good, if proper treatment be applied while the disease is limited to the mastoid. The danger of mastoiditis, either acute or chronic, lies not in that disease itself, so long as it is confined to the cellular structures of the mastoid process, but in the possibility of early and rapid invasion of nearby vital structures, and the strong probability that such extension will take place if the proper treatment of the mastoid inflammation be delayed or neglected. Mastoiditis as a sequel to chronic purulent otitis media rarely comes under the physician's care during its early stages, and when such cases do apply for treatment the prognosis

must always be a guarded one, because of the difficulty of ascertaining, prior to operation, the extent of destruction. If, by operating, the entire diseased area can be removed and general septicæmia has not developed, the prognosis is very good.

Treatment.—There are several well-established facts in connection with the mastoid inflammations which must be thoroughly appreciated before a judicious consideration can be given to the treatment of mastoiditis. In the first place, the fact that mastoiditis is a preventable disease stands out clearly. Eliminating the exceedingly small number of cases of primary inflammation of the mastoid bone, and the only slightly larger number of cases where secondary involvement of the mastoid cells has followed within a week of the occurrence of an infectious disease in the middle ear, and recalling the ætiologic factors in mastoiditis, the conclusion is reached that the majority of instances of this affection are due to improper treatment or neglect of purulent otitis media. Prevention of the disease is, then, the thing to be aimed at by all those who have the opportunity to institute such measures. Every case of suppurative inflammation of the middle ear, whether of the acute or chronic type, should be looked upon as probably already involving the mastoid antrum and affording the possibility for extension, through the mastoid cellular structures, to vital organs. The danger is not the same in all cases, but inasmuch as it cannot be accurately defined in any case, all purulent inflammations of the tympanum, especially the chronic ones, should be viewed as a menace to life. While it is true that many persons are seen who have been for periods of ten to twenty, or even fifty, years the possessors of an ear dis-

eased in this way, and which has never given them any
concern beyond that arising from the disagreeable fea-
tures of an otorrhœa, it is equally true that there was not
in all those years a time when their lives were not endan-
gered by the disease, and, furthermore, that medical rec-
ords are full of cases of just such lives being terminated
by an uncontrollable extension of the purulency to the
brain or the large blood vessels. No person who is the
victim of purulent otitis should be permitted to think that
his affection is a trivial one, and all cases of otorrhœa
should be carefully, scientifically, and persistently treated
until healed.

The second fact worthy of special note is the patho-
logic demonstration of the difference between simple mas-
toid inflammation and empyema, caries and necrosis of
the mastoid. Congestion and inflammatory infiltration of
the mucous membrane lining the antrum and small cells
may arise and subside again without leaving any serious
lesion; the invading microörganisms are destroyed, and
any exudate which may have been formed is cast out by
drainage through the tympanum, or by absorption through
the vascular and lymphatic systems. The production of
pus on a larger scale, the retention of pus, the molecular
destruction of the periosteum and bone, and the necrosis
of the mastoid structures, are pathologically but more
advanced stages of the same disease—possibly in a more
virulent form, possibly because it met with less resistance.
The clinical evidences may sometimes be very similar,
and it is often difficult to determine at what stage the in-
flammation stands. If the pathologic process were always
kept clearly in mind, however, there would be much less
occasion for discussion of the methods of treatment. The

first class permits of temporizing and antiphlogistic treatment; the second demands surgical intervention.

Abortive Treatment.—An unobstructed outlet for the products of inflammation forming within the tympanum and antrum being an essential factor in any plan designed to check a mastoiditis, it is of the greatest importance to secure an opening in the membrana vibrans adequate to permit free drainage. If perforation of the membrane has taken place, or if paracentesis has been performed, the opening may require enlargement. An incision made for this purpose should extend from the floor of the tympanum upward through the posterior segment to the roof. When there is much congestion about the inner end of the canal it may even be advisable to extend the cut outward in the supero-posterior wall of the canal, cutting through the skin and periosteum to the bone, and thus relieving the tension of and depleting the tissues under the floor of the antrum. Following the incision by warm irrigation promotes the discharge of inflammatory exudates, as well as removes any accumulated excretions.

Application of the artificial leech over the mastoid antrum and the withdrawal of 30 to 100 c.c. of blood is another effective means of depleting the hyperæmic bone, which may prove serviceable in some instances. Immediate relief from pain often follows this local bloodletting, and sometimes the improvement is permanent.

The employment of cold applications to the surface of the mastoid bone to prevent the spread of inflammation therein has long been considered a valuable therapeutic measure. The Leiter coil and numerous rubber ice bags have been devised for adaptation to the parts and con-

venience in securing a continuous icy application. Reduction of temperature and diminution of pain by this means unquestionably occurs in many cases, at least temporarily, but any marked influence upon the progress of the disease is not nearly so frequently apparent. Very often, indeed, the pain and fever recur as soon as the cold is withdrawn. Beneficial as it may be in some cases, it is not altogether harmless, and must be used with great caution. By disposing of the external evidences of a progressive inflammation in the bone—pain, fever, and redness or swelling—it may lure one to suppose a condition of improvement, when the disease is actually advancing rapidly by necrosis of the deep bone structures. When ice or iced water is thus applied it should be kept on continuously, not intermittently, but for a period not exceeding seventy-two hours; after from forty-eight to seventy-two hours' use it should be removed, and if the improvement which follows its application continues, the chances for success of further abortive measures are good; but if pain recurs or the temperature shows a rise, or, more particularly, if tenderness on pressure again becomes evident, there is not only little justification for, but positive danger in, continuing such tentative remedies.

Considerable discussion has taken place recently as to the relative merits of cold and heat in treating the early stages of mastoid inflammation. Some of the argument in favor of hot applications is certainly worthy of careful consideration. It is well known that some bacteria can remain alive in ice water for many weeks, and it is inconceivable that a sufficiently low temperature can be adduced in the mastoid by application of ice to its external surface to destroy or even interfere materially with the re-

production of the invading microörganisms. It would also appear that the influence of cold lessens the resisting power of the tissues, by contracting the arterioles and diminishing the quantity of blood supplied, and consequently the number of fighting leucocytes to engage in the contest. A sufficient degree of heat to check the growth of bacteria may be secured, and its influence upon vascularization and leucocytosis is at the same time a favorable one. It is impossible to bear either extreme heat or cold sufficient to sterilize an infected bone.

Drugs can play but a minor rôle in checking an inflammation of the mastoid bone. Complete rest in bed should be enjoined upon the patient, and careful attention given to the proper functioning of the excretory organs. For the maintenance of an open *prima via* in inflammatory conditions, calomel is especially valuable, mercury possessing, in addition to its cathartic powers, some tonic property and a marked detergent influence upon inflammation.

`Surgical Treatment.—The abortive measures referred to should be employed in the majority of cases of aural disease showing evidences of mastoid inflammation, and experience teaches that success will attend such efforts in a fair proportion of cases.[1] When tentative treatment fails to check the progress of inflammation, or when it can be determined at the first examination that empyema exists, immediate surgical intervention is demanded. The modern mastoid operation performed under strict aseptic technique is a comparatively dangerless proceeding. The dangers arising from prolonged temporizing, or undue delay in affording operative relief, are gener-

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[1] See Appendix, note 2.

ally more serious than the risks which attend the operation; in fact, the remote peril of anæsthesia is the principal, if not the only, evil factor to be considered in opposition to operating. When, therefore, a reasonable doubt exists as to the advisability of instituting operative measures, an exploratory opening of the bone is not only justifiable, but affords the patient the greatest possible assurance of safety. As has been explained, many cases of mastoid abscess occur in which one or more of the usual symptoms are poorly marked or even entirely absent. This makes it necessary, at times, to operate when an incomplete picture of the disease is presented, and only one or two symptoms are present to indicate the proper course to pursue. An infallible law as to the time for and conditions requiring intervention is as impossible of application here as in other surgical affections. The best that can be done is to establish an elastic code of signals that may serve as comparatively safe guides.

Indications for Operating in Mastoiditis: 1. Postauricular swelling, accompanied by fever and tenderness on pressure, when it can be shown that such symptoms are not due to inflammation of the meatus wall.

2. Persistent mastoid tenderness absolutely demands operation, regardless of the absence of other symptoms.

3. Bulging of the membrana flaccida, with drooping of the supero-posterior lining of the external canal at its inner end, particularly if this area be tender upon pressure with a cotton-tipped probe.

4. The continuation of otorrhœa, pain in the mastoid, and fever, in spite of several days' trial of antiphlogistic treatment.

5. The occurrence of chills, nausea, or symptoms point-

ing to meningeal irritation, even though the case may have been progressing apparently satisfactorily under palliative treatment; such symptoms being strongly presumptive evidence of invasion of the lateral sinus or brain.

6. The finding of streptococci in the pus from the middle ear is cause for extra caution, and if abortive remedies are not very promptly effective, operation is demanded earlier than would be the case were the causative agent a less virulent microbe.

7. Leucocytosis, found in conjunction with symptoms pointing to mastoid involvement, justifies an exploratory opening of the mastoid cells.

2. THROMBOSIS OF THE LATERAL SINUS

Pathology.—The occurrence of intravascular coagulation of the blood during life is always the result of disturbances of the circulation or of local pathologic changes in the vessel wall. Any alteration in the caliber of the vessels, or of the circulatory pressure which tends to retard the current, thus permitting the formation of eddies and the accumulation of the solid elements of the blood in the peripheral portion of the stream, favors thrombus formation at any available spot for adhesion to the vessel wall. Precedent chemical changes in the blood favoring the production of fibrinogenic substance need not be assumed in such cases as will be considered here, inasmuch as the formation of fibrin therein may be due to purely mechanical causes, and marantic thrombosis is not included in this study. Changes in the vessel wall, of a character which diminishes the normal power of the healthy intima to inhibit coagulation and slowing of the current, lead to the precipitation of blood plates upon

the affected portion of the wall.   The adhering plates rapidly degenerate into a granular, fibrinous substance, which entangles the corpuscular elements, and the deposit steadily increases until the lumen of the vessel is more or less completely occluded.   Under normal conditions, the blood current in the cerebral sinuses moves very slowly, and one of the conditions necessary to the formation of a thrombus is constantly present.   The second prerequisite —a roughening of the smooth inner lining of the vessel wall—is produced by extension of a purulent mastoid inflammation to the sigmoid groove and infection of the sinus wall from its external surface.   Conglutination at the injured spot forms a base for the further deposition of coagulable elements from the slowly moving blood, and the thrombus grows by accretion.   If a large area of the vessel wall is diseased the thrombus may have a considerable surface for adherence, and its attachment spreads along the course of the vessel.   So long as a channel for the stream is maintained the thrombotic mass is known as a lateral or incomplete parietal thrombus, and thrombosis of the vessel becomes complete only when its lumen is entirely obliterated.

Migrating suppurative otitis media is the most common cause of thrombus formation in the lateral sinus, and the portion of that vein in which the clotting most frequently commences is the sigmoid portion, lying at the inner aspect of the mastoid process in close proximity to the posterior mastoidal cells.   No part of the temporal bone is more variable than the groove on its inner surface designed for the lodgment of the sigmoid sinus.   It may be either comparatively shallow or very deep, rarely approaching the external surface of the mastoid cortex;

13

may follow its usual course downward and forward along the posterior border of the process, or be situated so far forward as to encroach upon the tympanic cavity. The most careful study of the external surface of the mastoid bone, as exposed during an operation, affords no accurate information regarding the location of the sinus. It seems to be the consensus of opinion that the sinus is apt to be larger and more superficial on the right side, and that, generally speaking, the narrower and more conical the shape of the process the closer the vessel approaches the antral region, and the more limited must be the field of operation when seeking to enter that cell by chisel or burr. Nor is it always possible, even at the time of operation, to trace with certainty the track of infection from tympanum or antrum to sinus wall.

In addition to the possible direct communication by means of canaliculi joining the mastoid cells and the erosion of intervening bone, consideration must be given to the small venous channels that drain the diseased bone directly or indirectly into the sinus. The small veins of the tympanum or antrum may become inflamed or thrombosed, and the phlebitis extend along their walls to the sinus. In the majority of instances the sinus is invaded only after a direct and prolonged attack upon its thick coat by a purulent process which has demolished the cellular structure of the mastoid, for not only is this the condition usually found when investigating a thrombosed sinus, but very frequently in simple mastoid operations the vessel is found to be exposed and bathed in pus, but not yet penetrated. The dural covering of the sinus is a very resistant tissue, but, of course, must give way before a virulent organism or the continued attack of a less

caustic enemy. When the vessel wall is inflamed, its intimal cells are soon infiltrated and become irregular in outline or undergo desquamation, so that the smoothness of surface normally presented to the blood stream is destroyed. At such a point clotting may readily commence, and as the inflammation is bacterial in origin the thrombus quickly becomes an infective one.

If thrombosis of the lateral sinus meant merely the closure of that venous channel, its occurrence would be a matter of small concern to anyone. The obstruction of such a vessel, however, by a septic barrier is cause for the gravest apprehension. The route from the sigmoid curve of the lateral sinus to the right auricle of the heart is a short and easily accessible one. During the formation of a septic clot at this point infected particles may become detached and washed quickly on through the jugular vein, or, even after obliteration of the sinus channel, toxines, bacteria, or portions of a decomposing thrombus may be absorbed or carried on into the general circulation.

Organization of a thrombus in the lateral sinus is probably of very rare occurrence. Disintegration, suppuration, and dissemination much more commonly take place, and general septicæmia is the logical consequence. Just as thrombosis of the lateral sinus may be the result of an extension of a thrombus originating in the petrosal sinus or one of the smaller veins passing from the antrum or tympanum immediately to the sigmoid, so an established clot in the latter may continue to spread along its course, past the jugular bulb, into the internal jugular vein and outward into the lumen of the smaller veins which empty into it from other directions, especially the condylar and mastoid emissary veins. It is the obstruc-

tion of these venous channels, and of the cavernous sinus, that occasions the œdematous condition of the neck and face so frequently noted in this disease.

The development of a thrombus in suppurative phlebitis is not altogether an offensive procedure; its very commencement, and especially its further growth, may be one of nature's most important defensive measures against the pyogenic invader. Extending for some distance beyond the infected portion of the thrombus may be an area of perfectly healthy clot which is in effect a well-guarded fortress, its fibrinous structure forming an entanglement for the advancing bacteria and the contained phagocytes constituting an active fighting force. If the infection is of a mild type the thrombus may become organized, the constituent elements of the clot undergoing transformation into fibrous connective tissue, and an effective barrier to the progress of mastoid erosion in that direction is formed. The virulent nature of the attack, however, is much more frequently such that purulent infection of the thrombus occurs, ulceration of the sinus wall follows, and the infective matter spreads along the dural covering of the vessel to the meninges, or is taken up by neighboring vessels and carried into the general circulation. Systemic infection is far more serious than the local effects of suppurative thrombosis. When nature's local resisting powers fail and pyogenic destruction of the thrombus goes on, disintegration of the mass is a matter that may well occasion grave alarm. The blood becomes charged with myriads of microörganisms, infective emboli are transported by the general circulation to distant parts of the body, and septicopyæmia with metastatic abscesses result. Such emboli may find lodgment

anywhere, but are particularly evident if they are arrested in the minute vessels of organs having a terminal circulation, where, through abrogation of nutrition, infection sets in; thus metastatic abscesses most frequently occur in the lungs, liver, kidneys, and brain.

Symptoms and Diagnosis.—Septic thrombosis of the lateral sinus originating almost invariably from purulent otitis media, it follows that practically every case thereof presents the history of an existent or preëxisting otorrhœa; and whereas the intervening pathologic changes between otitis media and sinus thrombosis usually consist of a progressive suppurative advance through the mastoid bone from the antrum to the sinus groove, there will be evidences of mastoiditis in most cases. Generally, then, a patient suspected of having this disease is found to have the previous history and clinical picture accepted as diagnostic of mastoiditis, some of the symptoms probably being of an exaggerated character and giving rise to the query, Has the necrotic process extended to the sinus, and, if so, how far is that vessel involved? No more important question can confront the aural surgeon, for upon his ability to promptly recognize such a phlebitis in its earliest stages may depend the life of the patient.

Among the many skilled observers and excellent surgeons who have painstakingly studied the problems connected with lateral sinus thrombosis, and who have contributed to our knowledge of the subject, none have done more toward enabling us to understand the pathology of the affection and to recognize its symptoms than Macewen[1] and Whiting.[2] To the latter especially the pro-

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[1] " Pyogenic Diseases of Brain and Spinal Cord," Glasgow, 1893.
[2] *Archives of Otology*, 1898, vol. xxvii, pp. 26–71 and 506–543.

fession owes a debt of gratitude for his masterly presentation of a detailed clinical picture of the disease from its incipiency to the end. Whiting's division of the condition into three distinct stages, based upon well-defined pathologic changes, so succinctly set forth in Macewen's work, affords a clear understanding of the situation, and a classification that is helpful in determining prognosis and treatment as well as diagnosis. According to Whiting,[1] " the course of sigmoid sinus thrombosis may be conveniently designated for purposes of clinical classification as comprising three stages, characterized by local and systemic manifestations: First stage: The presence of a thrombus, parietal or complete, not having undergone disintegration, and accompanied by slight or moderate pyrexia, rigors being usually insignificant or absent. Second stage: The presence of a thrombus, parietal or complete, which has undergone disintegration with resulting systemic absorption, characterized by frequent rigors and pronounced septicopyæmic fluctuation of temperature. Third stage: The presence of a thrombus, parietal or complete, which has undergone disintegration with systemic absorption, accompanied by rigors, rapid and great fluctuations of temperature, and central or peripheral embolic metastases, terminating usually in a septic pneumonia, enteritis, or meningitis."

The diagnosis in this first stage is not easily and surely made prior to opening of the mastoid cells. The detection of a thrombus so soon after its formation has most frequently happened during operations for mastoiditis, and when the pursuit of carious fistulæ or the

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[1] *Archives of Otology*, vol. xxvii, p. 510.

removal of granulation tissue and necrotic bone has caused the operator to expose the sinus and disclose its abnormal condition.   The symptoms occurring in association with mastoiditis, which should cause one to suspect interference with the sinus, are hemicrania, radiating over the entire side of the head, but not necessarily of a severe nature; tenderness in the upper part of the posterior cervical triangle and along the course of the mastoid emissary vein; and œdema of the neck in these regions.   None of these symptoms are so marked in degree as they will be in the second stage, but the fact of their existence at all in any case of mastoiditis should arouse suspicion regarding the state of the sinus.   Leucocytosis, with a great predominance of the polymorphonuclear cells, is generally much higher when the sinus is infected than when a simple mastoiditis exists.

When in the course of a mastoid operation the sinus is found to have been exposed to infection by the progress of a septic inflammation, the vessel must be most carefully inspected for evidences of thrombosis.   That the sinus is surrounded by diseased bone and its walls bathed in pus, or even that its external surface is covered by granulation tissue, is not conclusive proof that the disease has penetrated the vessel wall.   If a complete thrombus occupies the venous channel, that fact can usually be quickly ascertained.   Palpation elicits a feeling of doughy resistance, and aspiration fails to draw away fluid blood.   A partial thrombosis is not so readily determined.   Aspiration cannot be relied upon; the needle may pass through a parietal clot and secure blood from beyond, so the withdrawal of blood does not prove the nonexistence of a thrombus. Sometimes such a clot can be felt by the uneven manner

in which the vessel collapses under pressure by the finger.

The clinical features of the second stage are far more clear and more easily recognizable. The pathological boundary line between the first and second stages has been described as the point at which septic disintegration of the thrombus begins, and the clinical separation is based upon the apparent consequences of dissemination of this infected material. It is upon the recognition of the transition between the first and second stages that successful treatment depends, and a watchful eye should be kept for the earliest appearance of septic absorption.

A sudden chill is usually the first manifestation of septic absorption, and then follow the essential symptoms of blood poisoning of microbic origin; characteristic fluctuations of temperature, consisting of an irregular rise and fall, sometimes reaching an exceptionally high degree, and never falling as low as the normal; repeated chills followed by profuse and debilitating sweats; rapid pulse and respiration; loss of appetite; constipation; and possibly loss of consciousness, or delirium. An unusually high fever in mastoiditis should suggest the possibility of meningeal or vascular complications, but the occurrence of a sharp chill in such a case is the strongest reason for suspecting sinus involvement, and if the chill is followed by the irregular febrile condition, the temperature curve of which is indicative of general sepsis, the diagnosis of a crumbling thrombosis is absolute. The state of septicæmia may be reached and the disease proceed to a fatal termination without a chill or sweat having been noted, but such cases are atypical. The typical case history records the existence of constant headache, irregu-

larly high fever, and repeated chills followed by profuse perspiration. Many patients show at this time a peculiarly striking facial expression—the appearance of dread of some impending disaster; a look of alarm and fear. The symptoms related as possibly ascertainable in the first stage are all apt to be more prominent in the second; headache is constant and most severe; tenderness in the posterior cervical triangle and over the mastoid emissary vein is more marked; œdema of the soft tissues of the neck and puffiness about the eyelids are more noticeable, and occasionally ophthalmoscopic examination of the eye discloses the existence of optic neuritis. Tenderness along the anterior border of the sterno-cleido-mastoid muscle indicates extension of the inflammation to the internal jugular vein, and it is possible in some instances to feel that vessel as a small cord.

The third stage is marked by an intensification of all the symptoms previously spoken of, and by the advent of evidences of metastasis. Septic emboli once launched into the general circulation through the internal jugular vein may be deposited in the smaller arterioles in any part of the body. Statistics of reported cases show that the lungs are affected in this way far more frequently than any other organ, and pulmonary abscesses and septic pneumonia are frequently terminal affections to a latent sinus thrombosis. Enteritis, meningitis, and nephritis are, however, observed as complications, as well as more superficial abscesses.

Prognosis.—The prognosis of sinus thrombosis that arises from an infective otitis media is always serious. Spontaneous recovery is not unknown, but that it will occur in any given case can never be predicted, and must

be considered as extremely improbable. The vast majority of cases that are permitted to run a natural course terminate fatally, death usually resulting from meningitis or pulmonary or enteric suppuration as terminal features of septicopyæmia.

From what has been said, it should be perfectly apparent that the dangers of a septic thrombus arise but slightly from the local disturbances it may produce, but mainly from its disintegration and dissemination throughout the system. The prognosis, then, will be more favorable just in proportion to the early period at which a diagnosis can be made and proper treatment instituted for the thorough removal of the clot before its disintegration has commenced. If the infected clot can be taken away before the blood stream has become contaminated a fair prospect of recovery may exist. During recent years the general prognosis of this disease has rapidly improved, as earlier and more complete surgical treatment has been the rule. The operative technique has reached a point of high development, and future endeavor must be earnestly directed toward determining the most positive early indications of the formation of a thrombus, so that the advantages of surgical intervention may be made available at the most favorable moment.

Treatment.—In this disease there can be no debate over different forms of treatment. The instant the diagnosis is made, preparation should begin for immediate operation. The condition brooks no delay. Surgical intervention is imperative. The most favorable time for the removal of the thrombus is before its disintegration and dissemination have begun, and as the decomposition of an infected blood clot is a swift affair, the surgeon should

intervene with celerity in order to prevent the graver consequences of infection.

Whether as a continuance of a mastoid operation which has exposed an unsuspected sinus thrombosis, or as an operation instituted primarily for the abstraction of an inferred thrombus, the surgeon must work with the double object of removing as much as possible of the septic focus within the mastoid bone and the sinus, and preventing the spread of infective matter to the general circulation.

That a clear field of operation may be secured and no chance of inefficient work be taken, the whole sinus wall should be exposed from the knee down to the jugular bulb. Every precaution should be taken to avoid wounding the vessel's coat while removing its bony covering, and every visible particle of necrotic bone and septic material should be cleaned out of the mastoid process before the vein is opened. Furthermore, it is wise, as a rule, to ligate the internal jugular vein before attempting to break up the thrombus occupying the sinus. One can never be absolutely certain about the bacteriologic condition of the thrombus; it is presumably infected. To open the sinus and attempt removal of the thrombus piecemeal with the jugular venous channel patent affords the opportunity at least for an embolus to be passed on to the central circulation. The portion of clot below the starting point may look innocent and yet be very dangerous. To leave the jugular plugged at its bulbous portion by a clot of doubtful character is certainly risky. It can make little difference to the patient whether his jugular is obliterated a little below or a little above the angle of the jaw, and he is surely getting the advantage of conservative consideration when his vein is tied off at a point certainly

below any probably infected region. Ligation of the internal jugular is a simple operation that can be easily and quickly performed, and it adds scarcely any calculable risk to the main operation, while the sense of security which comes of knowledge that the main pathway of general infection is obstructed is invaluable.

Having ligated the vein and resected it as far upward as possible, tying off all large branches, the mastoid wound may again be uncovered and the sinus opened. Incision should be made in the long axis of the vessel and the clot removed first from the upper portion, the curette being employed to break up and withdraw the mass until a free flow of blood is established. By pressure of a gauze pledget on the vessel wall, above the incision, hemorrhage can be readily checked. Then the lower end of the sinus should be likewise curetted for the complete evacuation of all the thrombus. If the lower portion of the sinus and the vein have seemed to be healthy, the neck wound may be closed for union by first intention. The mastoid is to be dressed in the regular manner.

3. LABYRINTHINE SUPPURATION

The number of cases of labyrinthine complication appears surprisingly small when the frequency of suppurative middle-ear disease is considered, and the infrequency of reported observations in this field must be attributed to the difficulties in making accurate diagnoses from the clinical symptoms alone, and to the fact that proper exploratory operations have been developed only within recent years. Although a few cases of labyrinthine necrosis were recorded as much as thirty years ago, by Wilde, Toynbee, and Schwartze, it may truly be said that

all the valuable information concerning the pathology and treatment of this affection has been given to the medical world during the past five years. The rapid development of the operation of tympanomastoid exenteration, with its possibilities for inspection of the internal wall of the tympanum, has opened up a new and promising field for aural investigation.

Quite a series of instructive reports upon studies in this inviting region have recently appeared, but perhaps the most comprehensive and satisfactory are the monograph by Friedrich,[1] and an article concerning the operative treatment by Bourguet.[2] In the light of the knowledge gained from recent workers, it is quite probable that the diagnosis of labyrinthine suppuration will be facilitated, and that many cases will hereafter be properly classified which heretofore have been included under the broader diagnosis of suppurative leptomeningitis. On the other hand, it is more than likely that the actual number of cases of labyrinthine disease is decreasing, because of the improved methods of treating middle-ear suppurations. The most reliable statistics obtainable at present indicate that one case of labyrinthine suppuration occurs in every 100 cases of purulent middle-ear disease, or one per cent.

Aetiology.—In the majority of cases labyrinthine infection is secondary to chronic suppurative otitis media, but it may occur in acute otitis associated with a virulent attack of measles or scarlet fever. The constitutional dis-

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[1] "Die Eiterungen des Ohrlabyrinths," von E. P. Friedrich, Wiesbaden, 1905. Verlag von J. F. Bergmann.

[2] "Chirurgie du Labyrinthe." *Annales des Maladies de l'Oreille et du Larynx*, t. xxxi, No. 9, 1905.

eases which may be considered as ætiologic factors are scarlet fever, measles, influenza, and tuberculosis. That the acute exanthemata should play an important part as ætiologic factors is understandable, and it is a noteworthy fact that the reported cases show a predominant number occurring during the first decade of life, the condition of the bones in childhood probably explaining the tendency to sequestrum formation.

Among the cases resulting from a long-continued suppurative process in the middle ear, and without evidences of constitutional influence, a very considerable proportion belong to the type in which cholesteatoma formation is noted. Invasion of the labyrinth wall naturally follows where cholesteatoma produces destruction of the bone by pressure necrosis.

Not all cases of labyrinthine suppuration, however, result from middle-ear disease. Suppurative cerebro-spinal meningitis, whether of the epidemic form or of the infectious type following trauma, may invade the labyrinth through the internal auditory canal or by way of the aqueductus cochlea.

Pathology.—The wide variability of the pneumatic structure of the mastoid process is also reflected in the bony tissue surrounding the labyrinth. The cellular structure of the floor of the tympanum may communicate with similar spaces under the labyrinth, and the partition between the antrum and labyrinth may be composed largely of pneumatic cells. Through the accumulation of purulent secretions or the growth of cholesteatomatous material in the attic and aditus ad antrum, this cellular structure is subjected to caries or pressure necrosis, and the horizontal and superior semicircular canals are thus exposed

to invasion. While it is possible that the internal wall of the atrium may break down under the influence of an extensive caries, the promontory rarely presents an isolated fistula, but is only found to have been invaded when other portions of the inner wall have also given way to ulceration. A suppurative process in the tympanic cavity more readily enters the labyrinth through the oval or round windows, piercing the membranous covering of the latter or eroding the footplate of the stapes or its annular ligament.

The parts of the labyrinth particularly exposed to infection from the middle ear are, consequently, the vestibule, cochlea, and horizontal semicircular canal. According to Gerber,[1] the path of infection lies most frequently through the foramen rotundum, and in eighty-nine cases of labyrinth necrosis complete or partial destruction of the cochlea existed in seventy-nine (eighty-eight per cent). It seems probable that when a purulent inflammation enters the semicircular canals or the oval window it soon spreads to the vestibule and cochlea, but a limitation of the process to isolated areas of the canals or the vestibule is not impossible.

Extension of the labyrinthine suppuration into the cranial cavity usually takes place along the course of the auditory nerve or by way of the aqueductus cochlea, and the latter route is the more dangerous because it establishes direct communication with the subarachnoid spaces. When the superior canal is affected, and it encroaches upon the floor of the cerebral cavity, or this bony partition is marked by dehiscences, erosion into the subdural

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[1] "Ueber Labyrinthnecrose." *Archiv f. Ohrenhlk.*, November, 1903.

space is most likely. It follows that the most frequent serious consequences of labyrinthitis are suppurative meningitis and extradural abscess. Abscesses of the cerebrum and cerebellum and infective lateral sinus thrombosis occasionally occur as complications or sequelæ of suppurative labyrinthitis.

Symptoms.—The objective symptoms of labyrinthine disease are few and unreliable, prior to an operative investigation. A suppurative otitis media, usually chronic, is almost invariably present, and in most instances this has been the result of a recent attack of scarlet fever, measles, or influenza, or has been aggravated by one of the debilitating diseases like tuberculosis or diabetes. The only characteristic sign of bone disease in the labyrinthine capsule is the appearance of granulation tissue springing from the inner wall of the tympanum, with roughened, carious bone underneath. Pus exuding from the oval window, or from the promontory, particularly if it rapidly reappears after being wiped away, is of positive diagnostic value. Facial paralysis occurs very frequently with labyrinthine suppuration, because of the inclusion of the facial canal in the necrotic process, and whenever observed in connection with chronic purulent middle-ear disease should suggest a careful study of other symptoms that may point to invasion of the labyrinth.

The most suggestive subjective symptoms are tinnitus, deafness, and vertigo. Headache is a common accompaniment of all forms of temporal bone inflammation, and especially of their cerebral complications, and the febrile condition, likewise, in this affection shows nothing characteristic.

Tinnitus, when noted, has usually been an early symp-

tom, and with the progress of the disease was soon abolished. Marked impairment of hearing exists in all cases, and varies from a shortening of the lower or the upper tone limits to complete loss of function. Vertigo is the most constant symptom accompanying suppuration within the confines of the internal ear, and sometimes it is associated with horizontal nystagmus. In the early stages the vertiginous attacks may be followed by nausea and vomiting.

Diagnosis.—It is thus apparent that a positive diagnosis from preoperative inspection can seldom be made. In the majority of cases treatment must be instituted upon the basis of a probable lesion, the proof of whose existence depends upon exploratory operation.

It is said that nystagmus, when it exists, can best be illustrated by having the patient turn his head toward the unaffected side and fix an object in that direction. Disturbances of equilibrium seem to be aggravated when the head is turned toward the affected side, and, when under test, the staggering or falling is generally to that side.

Headache, fever, vertigo, and nausea are symptoms of meningeal and cerebral irritation as well as of labyrinthine disease, and tinnitus and deafness coexisting with these symptoms are not conclusive evidence of purulency in the cochlea or canals, hence the necessity for operative exposure of the inner wall of the tympanum to prove the diagnosis. Even then it will often require most careful search to find the portal of entry or exit of inflammatory products. Granulations protruding from the oval or round windows are easily recognized. Carious fistulæ in the semicircular canal walls or the promontory are not so readily discovered; they must be sought for with fine

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probes. Polypoid masses springing from the internal wall, at any point, are suggestive of bone caries beneath. When no fistula can be found, it may occasionally be observed that the semicircular canal presents a bluish or brownish discoloration, due to the appearance of granulations and blood clots as seen through the thin bony wall of the canal.

It has been said that suppurative meningitis is the most common sequel of labyrinthitis, and it is that which makes the prognosis of the latter disease a grave one. The similarity between labyrinthine and meningeal symptoms renders it all the more difficult to determine in any given case that meningitis has not been already incited. In some instances valuable information can be gained by the aid of spinal puncture. Suppurative meningitis is usually preceded by a stage of serous meningitis, and at this time, although the spinal fluid may contain no bacteria or cellular structures, it flows out with evidences of being under high pressure. Aside from the diagnostic importance of this measure, some prognostic information may be obtained by a study of the changing character of the findings if repeated punctures be made. As the meningitis increases in virulency, microscopic examination of the cerebro-spinal fluid will demonstrate the presence of cellular constituents, and, finally, of bacteria.

Prognosis and Treatment.—Purulent disease of the labyrinth is always dangerous. Surgical measures afford the only hope of satisfactory treatment, and every case of suppurative middle-ear disease presenting the complicating symptoms of fever, headache, deafness, and vertigo should be subjected to a thorough exploratory operation. The mortality of the operation itself is ex-

ceedingly small, whereas the mortality of unoperated cases of labyrinthine suppuration is very high.

The operation performed should consist of a complete mastoido-tympanal exenteration, and a sufficient area of the outer surface of the temporal bone removed to permit a clear view, under illumination, of the internal tympanic wall. When caries or necrosis of the labyrinth wall is discovered, the best results will be obtained by a thorough opening of the labyrinth and following the suppurative tract wherever it may lead. Should a perforation into the horizontal semicircular canal alone be found, for instance, it is not sufficient to clean out that area and stop, for pathological investigations have shown that the suppuration has usually extended to the inner recesses of the vestibule and cochlea; hence the vestibule should be opened below, and the oval and round windows connected by removal of the promontory. (See Appendix, note 8.)

Fairly satisfactory results will follow thorough surgical treatment even in the cases where serous meningitis has been previously established. In these operations no attempt should be made to secure primary closure of the postaural wound. Healing and epidermization of the cavity will be slow, requiring dressings for several months in some cases, and constant attention to prevent exuberant granulation in the upper parts of the wound is necessary.

4. CEREBRAL AND CEREBELLAR ABSCESS AND SEPTIC MENINGITIS

Aetiology.—Pyogenic microörganisms are the active agents of brain abscess in all cases. The introduction of bacteria to the cerebral cavity is gained through punc-

tured wounds or fractures of the skull, by the extension of purulent otitis media, or in consequence of transference by the vascular channels from some distant source of infection. Intracranial inflammation of otitic origin is more common than that due to all other causes combined, somewhat more than fifty per cent of all cases being traceable to chronic suppurative otitis media.

Pathology.—The pathologic process involved in an extension of suppuration of the middle ear to and through the mastoid portion of the temporal bone, the demolition of cellular structures within the mastoid, and erosion of the bony partitions that separate the tympanum and mastoid cells from the cerebrum, cerebellum, and lateral sinus, has been fully explained in the preceding pages. The actual attack upon the meninges and cerebral and cerebellar structures will be more fully considered now. Carious destruction of the tympanic and antral walls does not extend equally in all directions, but follows the line of least resistance. It thus follows that in some cases the suppurative tract is downward through the tip of the process into the digastric fossa; in others, posteriorly and internally to the cerebellar space or the sigmoid groove; and yet in others, upward through the roof of the tympanum or antrum into the cerebral cavity. When brain abscess follows erosion of the tegmen tympani it usually locates in the temporosphenoidal lobe; if it follows invasion of the sigmoid groove, the cerebellum is apt to be the site of infection.

Perforating erosion of the tympanum and mastoid is not generally a rapid process, nor a part of an acute inflammation in those regions. Most frequently it is the result of chronic, slowly progressing infection, and nature

has every opportunity to prepare whatever resistance is in her power. Advancing necrosis is always preceded by a zone of inflamed and infiltrated tissue. It happens, therefore, that by the time perforation of the bony tegmen is completed, irritation of the adjacent dura mater has led to the outpouring of a plastic exudate, and even to the formation of a resisting wall of granulation tissue. Such a barrier may prove sufficient to obstruct the devastating process, and even to assist in removing inflammatory débris. By fibrous organization of the exudate beyond the area of necrosis the dura becomes adherent to the healthy bone, and the condition is known as a limited external pachymeningitis; if pus collects in the circumscribed area it constitutes a subdural abscess.

More extensive inflammation of the dura or invasion of the pia and arachnoid may result from direct spreading of the disease to contiguous parts, and the issue will be a more diffuse pachymeningitis or a leptomeningitis. Direct and demonstrable extension of a necrotic path from tympanum to meninges is not always possible, in inflammation of the latter tissue following otitis, but an indirect route may often be traced through infective thrombosis of the small vessels running from the diseased bone to the cerebral sinuses or by septic emboli carried some distance from their source. Another mode of infection of the meninges, occurring especially in childhood, is by the filtration of pus from the mastoid cells through the still open petrosquamosal suture.

Pachymeningitis extends slowly and without serious symptoms until other and more delicate structures are involved. Leptomeningitis, on the other hand, spreads rapidly because of the weblike composition of the arach-

noid and the great vascularity of the pia mater. It is of much more serious import than inflammation limited to the external brain covering, and is soon complicated by infection of the cerebro-spinal fluid and involvement of the cranial and spinal nerves. The cortex of the brain and cord is seldom involved, but in some cases areas of œdema and softening of the superficial layers may be found, with some infiltration with pus cells. The inflammatory exudate is usually confined to the meshes of the arachnopia, and its distribution varies in accordance with the virulence and duration of the infection, sometimes being limited to a small area at the point of invasion, and, again, extending over almost the entire brain surface. Fibrinous in character, it holds in its meshes clusters of polynuclear leucocytes, bacteria, and a few epithelioid cells. The microörganisms most frequently obtained from culture, either at autopsy or from the cerebro-spinal fluid taken by lumbar puncture, are the pneumococcus and streptococcus. Purulent meningitis may be followed by abscess formation in any part of the brain or spinal cord, or death may occur from toxæmia before extensive lesions in the pia are produced.

As has already been said, infection may jump from the tympanum or mastoid to some portion of the brain substance, leaving the intervening bone and meningeal tissues perfectly healthy, or, proceeding along the course of some blood vessel, or by a scarcely visible necrotic canal, enter the cerebral substance and set up abscess formation. In the majority of instances of brain abscess resulting from middle-ear disease it is the white matter of the temporosphenoidal lobe that is affected, and the passage-way of the purulent process can be clearly traced through

the tegmen of the tympanum or antrum. The bacteria most commonly concerned are the Streptococcus pyogenes, Staphylococcus pyogenes aureus, and Pneumococcus, the same organism, as a rule, being isolated from the pus of the abscess as from the middle-ear discharge.

The next most frequent site of brain abscess is in the cerebellar lobe, and the necrotic route traversed is from the mastoid cells through the sigmoid groove. A brain abscess may gravitate to the surface, and, rupturing the meninges, discharge itself through the tympanum and external auditory canal, or may spread over the cerebrum and excite an extensive meningitis. Contrariwise, if molecular disintegration is checked and the tissues retain adequate animation, the abscess contents may undergo absorption or encapsulation. In the latter event, after an indefinite period of quiescence, renewed activity may be excited in the abscess by reinfection or traumatic disturbance.

Symptoms and Diagnosis.—Accurate differentiation of meningitis, sinus thrombosis, and encephalic abscess is always attended by difficulty and uncertainty, and when, as frequently happens, two or more of these conditions occur coincidently, confusion is greatly increased. By close attention to the localizing symptoms of abscess, the external evidences of venous obstruction, and the more or less characteristic features of meningeal irritation, a definite diagnosis is generally possible.

The clinical history of thrombosis of the lateral sinus has been given. Meningitis of otitic origin may occur independently of sinus or encephalic infection, or it may precede or follow suppuration in either vicinity; and the symptoms may vary, further, according to whether in-

flammation involves the dura or the arachnopia separately or together.

Since the majority of cases of all the mentioned intracranial affections result from purulent otitis media, and are directly or indirectly due to the ravishing progress of that disease, certain symptoms are common to all. Thus, very many cases, at the time the otologic surgeon is consulted, give the following clinical history: chronic otorrhœa, probably originating in an attack of one or other of the exanthematous fevers, has existed for a prolonged period, but the patient had become so accustomed to the discharge that it gave him no concern. Suddenly, as a result of reinfection or the occurrence of something which could excite the dormant microörganisms to renewed activity, symptoms of acute middle-ear inflammation arose. Pain in the ear and over the temporal region accompanied a general febrile condition. The mastoid region became tender to the touch, and its covering tissues more or less œdematous. The discharge from the ear may have increased in amount, changed in character, or, in some cases, ceased entirely. By elimination in diagnosis, other possible causes for the fever have been ruled out, and suppuration within the temporal bone is the one thing to be considered.

From this point the symptoms begin to vary, according to the route traversed by the suppurative inflammation and the nature and extent of the tissues attacked. The occurrence of a sharp chill at this time is strongly suggestive of intracranial invasion, and if it be preceded or followed by an irregularly high temperature the lateral sinus is almost certainly involved. A chill may attend the acute infection of any new structures, but is not com-

mon in the early stages of meningitis, and in brain abscess is associated with low temperature and slow pulse. Repeated chills and sweats are frequent in sinus thrombosis, but atypical cases do occur in which neither chills nor sweats appear at any stage of the illness. A well-kept temperature chart, recording temperatures taken at intervals of not more than two hours, is a valuable guide in determining the location of intracranial inflammation. A persistently high fever indicates leptomeningitis; a moderately low degree of fever, with occasional periods of subnormality, points to a collection of pus within the brain substance; while a zigzagging line on the chart, showing abrupt and radical rising and falling of temperature, suggests very strongly septic absorption from a disintegrating thrombus in the lateral sinus. Of course, such deductions can only be problematic.

Except for the localizing symptoms of impaired function that result from injury to or disease of specific areas of the cerebral cortex or of the cranial nerves, most of the other symptoms that occur in brain abscess and meningeal inflammation are of too general a nature to be helpful in defining the precise situation of a lesion. Optic neuritis has been found in cases of thrombosis as well as in meningitis and brain abscess; when present, it can only indicate excessive intracranial pressure. Nausea and vomiting likewise occur with all these conditions. Vertigo, convulsions, delirium, psychic disturbances, and loss of consciousness belong in the same category as symptoms that indicate serious intracranial disturbance, but point to no particular region as their source.

An examination of the cerebro-spinal fluid, in cases of suspected meningitis, may help greatly to clear the diag-

nosis. Lumbar puncture is a simple and harmless opera-
tion, and should be employed in all doubtful cases. If
the fluid thus obtained is not perfectly clear, or if a sedi-
ment is deposited after standing a while, it may be con-
sidered to be abnormal. Microscopic examination should
be made to disclose the presence of any pus cells or fibrin,
and cultures taken on suitable media for the propagation
of bacteria, which may not always be easily found in the
fluid specimens.

In view of what has been said above, it will be seen
that any grouping of symptoms under the respective dis-
ease headings can only be taken as suggestive.

External purulent pachymeningitis, or extradural ab-
scess, one of the most frequent complications of aural
suppuration, is rarely positively diagnosed prior to opera-
tion. There are no definite and characteristic symptoms.
Sometimes the picture is closely analogous to that of
encephalitis; in other cases—and the majority are em-
braced in this class—the subdural pus collection is only
discovered when operating for relief of an aggravated
mastoiditis. High fever, slow pulse, and severe headache
are the most prominent symptoms.

Diffuse Purulent Leptomeningitis.—The earliest symp-
toms are apt to be those of irritation of the meninges—
vertigo, vomiting, insomnia, rigidity of the neck muscles,
irregularity of pupil action, hyperæsthesia of the nerves
of sensation, and delirium. The headache is not generally
so violent as that of pachymeningitis. Temperature is
variable, rarely subnormal, but usually persistently high.
In the later stages, paralytic symptoms occur: dilatation
of the pupils, paresis of the external eye muscles, facial-
nerve paralysis, and hemiplegia. Optic neuritis of choked-

disk variety is often noted. Kernig's symptom—inability to extend the knee while in the sitting position—is a fairly constant one. Stupor, followed by coma and Cheyne-Stokes respiration, mark the fatal cases.

Cerebral Abscess.—With very few exceptions otitic abscesses have located in the temporal lobe. On the right side, except in left-handed persons, they cause very few focal symptoms. On the left, they produce the characteristic phenomena of aphasia.[1] A persistently low degree of fever, with occasional or continued periods of subnormal temperature, accompanied by slow pulse, is very characteristic of encephalitis; the pulse rate may fall below thirty-five per minute, and hold on between forty and fifty for days at a time. Headache, nausea, general restlessness and irritability, mental confusion and optic neuritis, mark most cases.

In some instances localizing symptoms, dependent upon involvement of a definite part of the brain, are apparent. The headache may be localized, and percussion on the skull over the abscess site increase the pain or elicit marked tenderness. The spot at which such tenderness is most commonly found is the posterior inferior angle of the temporal bone. The graver symptoms of the more serious cases are those of septic cerebral or spinal leptomeningitis, superinduced by rupture of the abscess and escape of pus onto the brain surface or into the ventricles.

Cerebellar Abscess.—Occipital headache, rigidity of the neck, severe vertigo, frequent vomiting attacks, and disturbances of muscular coördination, are the symptoms [2]

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[1] See Appendix, note No. 4.
[2] See Appendix, note No. 5.

depended upon for distinguishing between cerebral and cerebellar abscesses, but they will often be insufficiently evident to make a clear differentiation.

Prognosis.—Cure by absorption of purulent material deposited in the brain substance is an improbability. Encapsulation can occur and a long period of quiescence may ensue, but a permanent cure by this means must be rare. An abscess formation in the brain is likely to prove fatal unless surgical intervention is furnished. Macewen has shown that even the worst cases are hopeful if thorough operative measures be instituted as soon as the diagnosis is determined. Extradural abscesses may be easily evacuated, and, if not complicated by lesions of the arachnopia, the tendency is favorable. Pus cavities in the temporal lobe are not always accessible, but when found and cleaned out afford a satisfactory prospect of recovery. Cerebellar abscesses are less hopeful, because the route of infection has so often been by way of the sigmoid groove, and coincident invasion of the sinus has led to general sepsis. Leptomeningitis is least promising of all. Suppurative inflammation of the arachnopia spreads so rapidly and destroys vital structures so quickly that operative assistance will usually arrive too late. This should not deter the surgeon from lending his aid in any case, for a number of rather remarkable recoveries have resulted from operative intervention in apparently hopeless cases. With eradication of the mastoid and middle-ear disease, exposure of the infected meninges, by incision through the dura if necessary, and the repeated employment of lumbar puncture, a fair percentage of successes may be hoped for.

CHAPTER VI

MIDDLE-EAR OPERATIONS

OPERATIONS upon the drumhead and ossicles, and within the middle ear, are usually done through the natural channel of the external auditory canal. When this canal does not permit a sufficiently free access to the operative field, it is necessary to reflect the auricle forward, by means of a curvilinear incision through the integument and underlying soft tissues. This necessity is of comparatively rare occurrence, for, even when the external auditory canal is much narrowed, it is possible, under good illumination and with the exercise of an educated tactile sense, to do the majority of the minor middle-ear operations through the natural channel.

In all operations involving the opening of the tympanic cavity, especially in those applied to the relief of conditions incident to nonsuppurative disease, the careful sterilization of the canal, of the auricle, and of such parts of the head and neck of the patient as may come in contact with the hand of the surgeon, as already described, should be practiced.

In emergency operations, such as the incisions of the membrana tympani for phlebotomy, or to give exit to fluid, when the more thorough precautions of sterilization

are not possible, it is still important to have the hands of the operator, and the instruments and dressings which he uses, sterile, and to avoid contact of the former with the patient, and of the instruments with the walls of the canal.

PARACENTESIS

The simple operation of incising the drumhead is usually for the purpose of relieving blood pressure or of evacuating fluid contents of the middle ear; contents which may vary in quantity from a few drops to a body of fluid sufficient to fill the whole tympanum, and in consistence from the thinness of fresh serum to the thickness of inspissated mucus.

The point usually chosen for paracentesis for the evacuation of fluid is the posterior inferior quadrant of the drumhead, the incision varying in size from that of a simple puncture to a cut of five or more millimeters in length, made from below upward and parallel to the peripheral line of the drumhead.

For purposes of phlebotomy, in cases of acute congestion in the epitympanum, the incision is usually made along the posterior superior periphery, from below upward, ending at or near the short process of the malleus, and capable of penetrating to the deeper layer of blood vessels in the inner tympanic fold.

After incision, in acute cases with merely serous outflow, the ear should be wiped, plugged at the meatus with a piece of sterile cotton, or the canal filled with a loosely rolled absorbent-cotton wick extending as far out as the entrance of the canal; over this, and filling the concha, a second piece of cotton should be placed, directions being given for its renewal when thoroughly moistened by the

outflow from the ear, fresh cotton then being applied externally, but the drainage wick allowed to remain in place for several hours at a time, and changed only under conditions of careful sterilization of the hands which roll the wick and of the instruments which introduce it.

In the early stages of acute congestion where paracentesis has been done, observation of the character of the subsequent discharge, especially in relation to the amount of blood which it contains, is sometimes important. Under favorable conditions, with gradual subsidence of the congestion, the red blood corpuscles will gradually decrease and the discharge become more simply serous. In the event of unfavorable general conditions, overtire, faulty digestion, or some other cause for a recurrence of the congestion, which should be sought out and eliminated, the reddish color of the discharge returns.

In following such a case, it is well to have the wicks removed from the ear preserved, at three-hour intervals, placed upon a piece of paper separately, and with a mark on the paper indicating the time at which each wick was removed, the whole being covered with a moist cloth and preserved for inspection of the surgeon.

Should the discharge become thickened, by the entrance of mucous elements, or in the event of purulency, the wicking should be abandoned in favor of syringing, and the canal stopped lightly with a dossil of cotton.

If the fluid to be released from the middle ear is thick and tenacious, a larger incision in the drumhead is required than when it is thin and flows freely, and evacuation may be assisted by autoinflation of the middle ear, by Politzerization, the use of the catheter, or by means

of the pneumatic speculum and suction. When the secretion is so thick that only a small beadlike portion extrudes, as is not uncommonly the case with prolonged closure of the tympanopharyngeal tube and partial rarefaction of air in the tympanum, the so-called hydrops ex vacuo, this may be touched with a weak solution of argentic nitrate on a cotton-tipped probe, the resulting coagulum affording a hold to the forceps, by means of which the tenacious mass may be withdrawn.

Regarding the sound-transmitting mechanism of the middle ear as an acoustic balance, its two outermost tension factors are the resistant membrana vibrans and the persistent traction of the tensor tympani muscle, the one a passive and the other an active element. Weakening of the passive resistance of the membrana vibrans, whether by a stretching of that membrane or from a solution of its continuity, is to be avoided as far and remedied as much as possible. Incisions in the drumhead, for the purpose of liberating fluid contents of the tympanum, should be made, preferably, posterior to the line of greatest tension resistance to the inward pull of the tensor tympani muscles, a line of mechanical consideration, marked by no special structure, but sufficiently indicable, for surgical purposes, as a continuation of the line of the long axis of the long process of the malleus, really slightly anterior to this, and the area in which the progressive growth of the dermoid coat of the membrana vibrans parts, anteriorly and posteriorly. A paracentesis of the drumhead, made parallel to the periphery and from two to three millimeters within it, affords sufficient drainage from the tympanum, and weakens the membrana vibrans less than a similar incision made anteriorly.

The obstructive changes occurring in the middle ear in the course of, or subsequent to, a nonsuppurative disease are so varied in location and extent as to make the question of the success of operation for betterment of hearing, relief from circulatory tinnitus, or from virtiginous symptoms, an uncertain one, without better preliminary knowledge than is inoperatively obtainable. Hearing tests, covering a wide range of tones, serve in some measure to determine the location of obstructions (see Appendix, note 7), and an incision of the drumhead, for the purpose of altering its tension or of permitting sound waves to pass through it, is available as a means of determining the mobility of the parts of the ossicular chain beyond the malleus. Attempts to maintain a permanent opening in the drumhead, when its exploratory puncture has effected an improvement in hearing, have, however, been uniformly unsuccessful, on account of the vigorous reparative power of the membrane. In default of success in sufficient mobilization of the sound-transmitting apparatus by other means, exploratory invasion of the tympanum, to a greater extent than that comprised in a simple puncture of the drumhead, becomes a matter for consideration.

Operative mobilization of the ossicles may be effected by making a triangular cut in the posterior superior segment of the drumhead, opposite the descending process of the incus and the stapes, and the introduction of a small blunt hook. The objections to this method of operating are the smallness of the field exposed and the consequent difficulty of manipulation. The location of the opening, in the center of an important segment of the membrana

15

vibrans, is of less importance, as fresh incisions in the drumhead heal so readily that attempts to maintain a permanent opening by excising large portions, by the use of escharotics and by introduction of eyelets, have mainly failed in that purpose.

To permit free access to the middle ear in the line of the ossicular chain, to avail of the intelligent participation of the patient, and, if any operation more serious than an attempt at mobilization should be found to be unjustifiable, to permit the immediate closure of the opening in the drumhead and the restoration of the parts to their former position, the operation constituting an exploratory tympanotomy was devised. This operation consists in an incision along, and close to, the posterior-superior periphery of the drumhead, beginning at a point opposite or slightly above the round window, and ending close to the handle of the malleus below the short process; the dendritic fibrous tissue in the flap thus formed tends to pull it downward and outward, exposing, often without the need of manipulation, the descending process of the incus and the stapes, and permitting tactile access to the tensor tympani tendon and the tendon of the stapedius. The operation should be done, preferably, without general anæsthesia, thus making hearing tests during progress possible. It is comparatively painless, if the cut is made close to the periphery, avoiding contact with the skin of the canal. In especially sensitive patients the incision may be suspended in its lower third and a sterile cocaine solution applied. Hemorrhage, even in the upper part of the cut, is usually inconsiderable, and can be easily controlled by sopping with a dry cotton-tipped probe.

In a series of experiments on the progressive growth

of the dermoid coat of the membrana vibrans, it was found that the movement outward from the center of the membrane, at the tip of the malleus, toward the posterior and superior periphery, was slowest in the inferior third of the segment, more rapid in the middle third, and most rapid in the upper third, and that the rate of movement, as shown by small pieces of paper pasted upon the membrane, bore a proportionate relation to the corresponding degree of vascularity of the three sections mentioned. Tactile examination shows that the sensitiveness of the sections of the posterior segment of the membrana tympani have the same relative correspondence, and that an incision, therefore, begun opposite the round window, causes increasing pain as it is extended upward and forward along the periphery.

A part of this progressive increase in pain can, of course, be accounted for psychologically, but it is evident that the edges of a small and comparatively painless cut, by affording access to the mucous membrane forming the inner coat of the membrana tympani, can be availed of for purposes of local anæsthetization, and that the cut can be successfully continued, under the same influence, with comparatively little discomfort. Tactile investigation as to the comparative sensitiveness of different portions of the tympanic cavity also show its lining membrane and intrinsic structures, with exception of the superior and posterior portions, fornic tympani, and aditus ad antrum mastoideum, to be comparatively insensitive, especially in the line of the sound-transmitting apparatus of the middle ear.

Operations within the middle ear, therefore, except such as include interference with the membrana vibrans

and invasion of the upper portion of the tympanic cavity, may, in the great majority of nonsuppurative cases, with proper care, be conducted not only without general but also without local anæsthesia; and in the cases of chronic nonsuppurative disease of the middle ear with intact membrana tympani, to which this operation of exploratory tympanotomy is applicable, when the sensitive membrana tympani has once been passed, there is opened to the observer an aseptic and comparatively insensitive cavity.

The successive stages of the exploratory tympanotomy are: First, the crescentic incision, beginning in the posterior segment, and carried upward and forward through the thin and comparatively insensitive portion of the drumhead between the annulus cartilaginous, the massed bundle of fibers of the circular fibrous coat of the membrana vibrans, and the periphery, then downward along the posterior border of the handle of the malleus. (Fig. 22.) This cut may sometimes be completed without with-

Fig. 22.—Line of incision for exploratory tympanotomy.
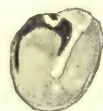
Fig. 23.—Flap turned outward, exposing the stapes and inner tympanic wall.

drawing the knife, but usually it is necessary to suspend it when the upper portion of the drumhead is reached, either for the purpose of making an anæsthetic application or to allow the patient a moment's rest. Almost immediately upon the completion of the incision the flap thus formed curves downward and outward, revealing the descending process of the incus, and sometimes the posterior crus of

the stapes, the stapedius tendon, and the corresponding portion of the inner tympanic wall. (Fig. 23.) Bleeding from the cut edges is taken up by the cotton stick and the wound allowed to glaze. During this period of waiting the prescribed hearing tests should be made and recorded.

Second, a small blunt hook, previously dipped in alcoholic boric-acid solution, is passed through the opening, care being taken to avoid the cut edges and inner surface of the flap, and the mobility of the malleus tested by a series of gentle pulls, the same process being repeated by passing the hook behind the descending process of the incus and under the head of the stapes, the various degrees of fixation or of mobility being determined by this means.

Third, if it is decided to close the opening in the drumhead without further manipulation in the middle ear, or at the conclusion of such manipulations as may include division of adhesions or obstructive striæ crossing the tympanum, or binding the stapes to the walls of the fenestral niche, there is cut from a small piece of thin, highly glazed paper, by means of curved scissors, a disk large enough to cover the flap formed in the drumhead and to extend upward over its periphery on to the inner end of the external canal. This disk, dipped in sterile water or normal salt solution to moisten its sizing, is then taken upon the end of a wet, cotton-tipped probe and its lower half brought into contact with the outer surface of the flap in the drumhead, and held in position for a few seconds until it adheres, when the paper, carrying the flap with it into position, should be similarly attached to the skin above the incision, thus bringing the edges of the

crescent cut into a position and holding them firmly in place. The patient should be directed not to practice auto-inflation; the ear should be lightly stopped with sterile cotton, and this dressing allowed to remain in place until the healing of the drumhead, which usually occurs within three days.

In the second stage of this operation there may be included almost any form of interference in the line of sound-transmitting apparatus of the middle ear other than evulsion of the two larger ossicles. It is even possible to disarticulate the incus and stapes, cut the tendon of the stapedius and extract the stapes, and the incus also, through such an opening as that described.

STAPEDECTOMY

The operation of stapedectomy, while very simple in itself, is open to question as to its advisability, because of the varied consequences which may follow invasion of the cavity of the internal ear, and because of its doubtful value for the purpose for which it is usually demanded, amelioration of an extreme degree of deafness. Recent clinical experience in the relief afforded in cases of severe and incapacitating vertigo, by removal of the stapes, warrants a consideration of this operation. It should be borne in mind, however, that the fixation which causes extreme symptoms, either of deafness or vertigo, is not infrequently only secondary to a hyperostotic process in the labyrinthine capsule, which removal of the stapes cannot relieve; that, under these conditions of fixation, the crura not unusually break in the attempted extraction, and that there then remains only the alternative of drilling or of breaking up the base plate.

In twenty-one consecutive cases of attempted removal of the stapes, in chronic nonsuppurative disease of the middle ear, with a view to the improvement of hearing, the stapes was removed entire in nine cases only; there was fracture of both crura in ten cases; and in two cases the bone was found to be so absolutely immovable as to make it possible to rotate the head of the patient in a sitting position, by traction upon the blunt hook inserted between the crura. In six of the cases, which had not before been dizzy, vertigo, more or less severe, followed the operation, in three cases persisting for more than a month, and in one for nearly a year; in but three out of the twenty-one cases was there other than temporary improvement in hearing, and then only in a moderate degree.

That the condition of the sound-transmitting apparatus of the middle ear plays an important part in the causation of vertigo, as well as in disturbances of hearing, is liable to be overlooked in the consideration of the other reflex factors in any given case; but a study of the vague, recurrent vertigoes as they come under the care of the neurologist gives increasing evidence that some form of fixation of the sound-transmitting apparatus of the middle ear constitutes the constant factor, and some suspension of vasomotor inhibition the variable factor in many of them.[1]

Given a fixation of the stapes, either individually or through the members of the ossicular chain, a portion of the compensating elastic provision against interlabyrinthine pressure, from a suspense of vasomotor inhibition, is lost, this loss varying in its extent with the degree of

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[1] See Appendix, note 6.

stapes fixation from that pertaining in the simple, general immobilization, to that attending supreme fixation, by bony anchylosis, of the stapes itself.

In attempting extraction of the stapes, care should be taken to divide all adhesions between its crura and the environing niche walls, as well as the tendon of the stapedius muscle; the incisions around the niche walls should be carried to the depth of that depression, after division of the stapedius tendon; to determine any possible degree of mobility which may remain, hearing tests, if the operation is performed without general narcosis, being also instituted as an aid to determining the advisability of removing the bone. Simple mobilization of the stapes, previously detached from the incus, being made the preliminary in the cases in which stapedectomy is found to be unnecessary, to the reflexion of a drumhead flap upon the stapes, or to removal of the drumhead and the two major ossicles, with a view to utilizing the mobility of the stapes by insertion of some form of artificial drumhead.

MALLEO–INCUDECTOMY

In cases of high grades of deafness where there is a possibility of utilizing the stapes, the major ossicles being firmly bound by bony anchylosis, their removal, together with the whole or part of the drumhead, may be effected by making a circular incision, close to the periphery, by means of a narrow-bladed middle-ear bistoury or a paracentesis knife, dividing the anterior and posterior striæ of the short process of the malleus in like manner, and the incudostapedial articulation and tendon of the tensor tympani by means of an angular knife; extracting the malleus and incus either together, by means of a wire

passed around their long processes, or separately, the malleus by means of the snare or fixation forceps, and the incus by means of an incus hook or curette. The tendon of the stapedius muscle can next be divided by means of a slender paracentesis knife, and the knife also passed about the stapes in the fenestral niche, to divide the adhesions which find their location there. If, instead of excising the drumhead, the anterior and posterior portions have been retained, by making the incisions releasing the malleus along the anterior and posterior borders of its long process and then unitedly down to the periphery of the drumhead, these anterior and posterior portions, in size sufficient peripherally, may be carried forward to cover the tubal opening and backward for attachment to the stapes, the intact mucous membrane on the anterior tympanic wall having been pre-

Fig. 24. — Perforation of pars flaccida and of posterior segment, with granulomata from carious incus and head of malleus. Anteriorly, the line of incision for formation of anterior drumhead flap.

viously curetted, or dry-scrubbed to the extent of bleeding. (Fig. 24.) The flaps should be kept in place by light tamponage with sterile absorbent cotton.

SYNECHOTOMY

After-results of suppurative middle-ear disease, thickening of mucous folds in the epitympanum, the formation of adhesions limiting the movements of the ossicles, and cicatricial membranes growing inward from the edges of the perforation of the drumhead and interfering with sound transmission, need to be dealt with surgically, according to their destructive importance. The common locations of adhesions are between the long process of

the malleus and the inner tympanic wall, and around the stapes and into the fenestral niche; while the thickening of the mucous reduplications, normal in a large majority of middle ears and often filling the lower limit of the epitympanum, serves to keep the ossicles in the abnormal position into which they are drawn, by contraction of the tensor tympani muscle exerted when the counterbalancing tension of the drumhead is removed.

The extension of a cicatrix from the posterior edge of a large perforation of the drumhead inward upon the inner tympanic wall will sometimes inclose the round window in an individual space. Under this condition, absorption of air in the inclosed space, or the exudation of fluid into it, will so far impair the movement of the round window as still further to decrease the hearing; puncture or incision of the cicatrix being required for relief.

In all tentative operations for improvement of hearing, by divisions of adhesions and mobilization of the ossicles, if the suppurative process has run its course and the ear has become dry, it should be remembered that there is a possibility of awakening acute trouble, and that, unless complete evulsion of the larger ossicles is intended, mobilization had best be gradually effected in successive stages, and preferably without general anæsthesia, in order that the effect upon the hearing may be progressively tested.

In the event of a large perforation of the drumhead with the tip of the malleus adherent to the promontory, and other adhesions obstructing the movement of other members of the ossicular chain, the first step should be the division of the adhesions at the tip of the malleus and gentle mobilization of that bone by means of a blunt hook.

If it is decided to suspend interference at this point, the middle ear should be carefully dried and lightly packed with sterile absorbent cotton, a dossil of cotton being placed behind the malleus to prevent recurrence of adhesions. At subsequent sittings other bands and adhesions may be divided, circumcision of the stapes may be done, and tenotomy of either the tensor tympani or stapedius muscle. It is occasionally possible, in cases of firm anchylosis of the ossicles without fixation of the stapes, to utilize the ossicular chain as a columella by dividing the tendons of both the stapedius and tensor muscles and inserting an artificial drumhead.

In all cutting of adhesions, especially those which are extensive and unite parts of the ossicular chain to immediately contiguous parts of the tympanic wall, the liability to union of the cut surfaces should be counteracted, either by the separation of these surfaces by packing with sterile absorbent cotton or gauze, or by the insertion between them of small pieces of paper, very thin rubber tissue, or thin plates of metal, folded gold or silver leaf answering the latter purpose.

CLOSURE OF PERFORATIONS

In suppurative middle-ear disease operation is usually undertaken with a view to affording exit to morbid products, and access to diseased parts for purposes of removal or of curative application, the betterment of the hearing, in the more serious cases, being a secondary consideration.

A common result of suppurative middle-ear disease is a persistent opening in the drumhead, and if the middle ear has become dry and the mobility of the ossicular

chain is comparatively unimpaired, closure of the open-
ing affects an improvement in hearing. This is easily
tested by covering the perforation with a disk of mois-
tened paper, and if the result is favorable, the paper may
be allowed to remain, to assist in the permanent closure
of the opening.

The edge of an old perforation of the drumhead con-
sists of a thin line of cicatricial tissue, or of a union of
the outer, dermoid, and inner mucous coats, in the form
of a transition membrane, both of which structures are
inimical to proliferative growth and must therefore be
removed. This may be done by scraping or cutting with
a thin-bladed knife, the cut edges of the perforation being
then wiped dry and a disk of thin sized paper, floated and
moistened in sterile water or normal salt solution, picked
up on a cotton-tipped probe and gently applied; immedi-
ately upon contact with the dry, warm surface of the
drumhead the paper leaves the wet cotton tip and adheres
to the membrane, this adhesion being favored by manipu-
lation and patting with a dry cotton-tipped probe, which
also absorbs the superfluous moisture. Autoinflation of
the ear for at least twenty-four hours after the application
should be avoided.

The stiff adherent paper not only pulls upon the rim
of the perforation with every major vibration of the drum-
head, causing an irritation which stimulates new growth,
but also serves as a protection and a guide along which
the nascent tissue may progress. This application has
been found serviceable not only in dealing with smaller
perforations, one dressing sometimes sufficing, but also in
the building up of larger cicatrices, where a principal por-
tion of the drumhead has been destroyed, and where it has

been necessary to apply the paper to successive portions
of the rim, and to occupy several months in the healing.

In making paper applications to the drumhead or
within the middle ear, the paper to be applied should be
thin, ordinary note paper, but with sufficient sizing to
afford an adhesive surface when moistened; for this pur-
pose the ordinary highly glazed foreign post paper is
preferable, and, if white, it is more easily seen in the ear
than if colored. It should be cut from the sheet with as
little handling as possible, and shaped with a pair of
curved manicure scissors to fit or cover the surface to
which it is to be applied. After a moment's floating in
sterile water it should be dipped beneath the surface with
a firmly cotton-tipped probe, lifted from the water by
means of the probe, adjusted upon the tip of the probe by
touching its edges only with the finger, and then intro-
duced under good illumination. As the small disk of
paper is really floated on the probe by a drop of water,
contact with hairs or with the wall of the canal will easily
displace it; it is necessary, therefore, to carefully cleanse
the canal walls before attempting to apply the paper, and
to introduce it with a steady hand. If the cotton on the
probe is firmly twisted to a length of one centimeter be-
yond the end of the probe, it affords a malleable tip,
which may be curved in the position for carrying the
paper which will best facilitate its introduction.

When applied to cover a perforation or scar in the
drumhead, the lines of growth of the dermoid coat should
be had in mind, the paper cut in an elliptical form, and
applied with its long axis corresponding with the line of
movement; or, if overlays are to be used, they should also
be applied in a reverse position to the line of movement.

TREATMENT OF TENSION ANOMALIES

The portion of the membrana vibrans most subject to weakening, by stretching, is the posterior-superior segment. Stretching of this segment by repeated forcible variations in air pressure in the tympanum as the result of excessive autoinflation, mechanical air compression in the nasopharynx, or, reversely, incident to obstructed nasal breathing, or by variations in air pressure in the external auditory canal by injudicious use of pneumatic massage apparatus, evidences itself in the counteracting effort toward maintenance of acoustic balance, by contraction of the tensor tympani muscle, and, symptomatically, by defects in hearing, especially for tones of low pitch, and by a liability to flatting in the tones of the singing voice, especially in that portion of the register in which minute differentiation of tone quality is requisite.

The most readily applicable remedy for this condition is the supporting application of a disk of paper, so placed as to impinge upon the upper canal wall. If the stretching is excessive or irregular in contour, as is liable to be the case when the stretching includes the thin area outside of the thicker mass of the circular fibers of the membrana propria, then use successive applications of contractile collodion, applied by means of a small brush made by twisting cotton on the end of an aural probe.

When the stretched portion has become firm, an effort may be made to counteract the traction of the tensor tympani muscle by moderate, prolonged rarefaction of air in the external auditory canal; this can be effected by stopping the meatus tightly, preferably before retiring at night, and on alternate nights, with a conical plug of

absorbent cotton and simple cerate well rubbed together. The skin lining the canal is capable of absorbing sufficient air, from the space closed by the plug at one end and by the membrana tympani at the other, to create a partial vacuum, the resultant preponderating air pressure on the inner surface of the drumhead, which should have been reënforced by an additional collodion application over its previously stretched portion before the series of pluggings is instituted, gradually counteracting the pull of the muscle. When successive collodion applications are made, care should be taken to keep the extent and frequency of the applications within the limit of exciting localized inflammation, and possibly ulceration of the tissues of the drumhead.

In cases where the drumhead is firm, but undue contraction of the tensor tympani muscle has resulted from prolonged preponderating air pressure on the outer surface of the drumhead, incident to successive closures of the tympanopharyngeal tube and rarefaction of air in the tympanum, the application of the plugging process is a valuable precedent to other forms of treatment which may be employed for the restoration of the normal mobility of the sound-transmitting apparatus.

Another means of counteracting the pull of the tensor tympani muscle, and for effecting mobilization of the malleoincudal articulation, is afforded by pressure upon the short process of the malleus by means of a pressure probe, or else an aural probe tipped with a firm boss of cotton, the pressure being effected by a series of concussions, continued so long as may be without discomfort and repeated at clinical intervals. A more protracted but lesser degree of pressure may be exerted by the wearing

of a cone of paper, or a disk or strip of rubber so placed in the canal as to exert pressure upon the short process of the malleus.

The artificial drumhead has for its purpose either the tension of relaxed parts of the sound-transmitting apparatus of the middle ear, the apposition of loose connection, or the substitutive presentation of a surface for the reception of sound waves. One of the earliest forms of artificial drumheads was a moistened spiral of paper or a small ball of cotton, and despite the exercise of much ingenuity in the construction of various forms of artificial drumheads, and the application to that purpose of a great variety of substances, the paper and the cotton still remain the most utilizable for effecting the desired purpose.

The paper, thin rubber, or woven tissue drumheads may be inserted either by means of an attached wire, or by means of a thread passed through and knotted at the center of the drumhead and carried through a small glass tube which serves as a handle for purposes of insertion merely, or the thread may be grasped with forceps and introduced in that manner.

Absorbent cotton used for the purpose of an artificial drumhead has the advantage of adaptability to the case in hand, as it can be rolled into a small ball, to which a thread may be attached, twisted into globular shape with a projecting tail-like end, or, the tail-like end being elongated and dipped into collodion to make it firm and usable as a handle, the remaining portion of the cotton may be moistened with water, flattened by pressure between the fingers into the form of a disk, dried, and then dipped

into melted vaseline for introduction. In all instances, the artificial drum needs to be moistened for use, the preferable fluid being one of sufficient density to equally fill the interstices of the cotton, and of a sufficient fluidity to permit adjustment of the cotton drum to an irregular surface. Melted vaseline best answers this purpose. In the process of melting it is rendered sterile, but as it long retains heat, care should be taken to allow the moistened cotton a sufficient time to cool before introduction.

In cases where there is a large perforation of the membrana tympani, or where the membrana tympani and the two major ossicles are wanting and the stapes is movable, the cotton-vaseline drum may be applied, filling the tympanum and bearing upon the stapes, its ultimate position as pressed into place by the angular ear forceps being best determined by experimental tests for the hearing of the voice. Undue pressure on the stapes will tend to impair rather than to improve the hearing, and it is sometimes necessary to bring an equal degree of pressure of the cotton-vaseline drum upon the stapes and upon the membrane of the round window to get the best effects.

When the tympanum has become dermatized, a cotton-vaseline drum can be worn for several days together, and the same is true even in the case of a continued suppurative process; but in no case should the artificial drumhead be allowed to interfere for too long a time with the cleansing of the middle-ear cavity.

In cases of supreme fixation of the malleus, with comparative mobility of the incus and stapes, the rapid reparative power of the drumhead may be availed of to attach it to the descending process of the incus, thus translating to the more mobile bone the vibrations of the still func-

16

tionating membrane. This procedure consists in making the triangular opening in the posterior-superior segment of the drumhead, opposite the incus, in such position and of such extent as to reveal the descending process in its lower portion; the proximate surface of the process should be curetted, and the triangular flap brought into contact with it and so maintained, by the insertion of a light, conical, absorbent cotton plug, a superimposed dossil of cotton filling the inner end of the canal and serving to keep it in place. When done under aseptic precautions the healing is usually speedy and effectual.

OSSICULECTOMY IN SUPPURATIVE MIDDLE-EAR DISEASE

In the event of a considerable necrosis of the two larger ossicles, or when their presence presents an obstructive barrier to drainage from the epitympanum and bars access to diseased parts, their removal is indicated. This operation should be done under general anæsthesia, not only because it is painful, and may need to be considerably prolonged on account of the delay incident to obscuration of the small field by free bleeding from granulomata, but because a thorough examination and possible curetting of the tympanic walls is a part of its purpose.

The instruments required are virtually the same as those used for the similar operation in nonsuppurative cases, and are, in addition to specula, blunt probes, cotton sticks, paracentesis needles, a slender curved bistoury, and a spatula-shaped knife for division of adhesions in the epitympanum, an angular knife for division of incudo-stapedial articulation and for cutting the tendon of the tensor tympani muscle, a wire snare, or a pair of fixation forceps for the extraction of the malleus, an incus hook,

or blunt angular curette for removal of the incus, and a small blunt hook for use about the stapes; there should also be a saturated solution of boric acid in alcohol, and a solution of extract of suprarenal capsules, the former for dipping the instruments, and the latter for controlling the sometimes annoying bleeding.

If the perforation is in the pars flaccida, the drumhead being intact, or if the perforation of the drumhead is small and the middle-ear disease extensive, the entire removal of that membrane accompanying the evulsion of the malleus and incus may be advisable, or the posterior portion of the drumhead may be retained, to be carried inward and attached to the head of the stapes, while the anterior portion, released by incision at its inferior periphery, may be used as a flap to shut off from the middle ear the opening of the tympanopharyngeal tube.

In this, as in most other middle-ear operations under general anæsthesia, two assistants should be employed with advantage, one to etherize and to control the position of the head of the patient, who should be preferably in a sitting or semiprone position, the other to twist cotton sticks, cleanse and dry the instruments, and hand them to the surgeon when he wishes to keep his operative field continuously in view. Before using, and after each successive cleansing and drying, the blades of the instruments should be dipped in the alcoholic solution of boric acid, the speedy evaporation of the alcohol leaving the steel covered with a thin film of boric acid, which dulls the metallic luster and makes the instruments more plainly visible in the canal.

Partial or complete peripheral excision of the drumhead should be done with the paracentesis needle or

curved bistoury, the membrane being, in addition, stripped
from the handle of the malleus for the sake of removing
an obstruction to both sight and manipulation, and of mak-
ing the malleus and the parts beyond it more accessible.

If the incus is in place, and it is desired to remove it
also, either previously to or simultaneously with the re-
moval of the malleus, the next step should be the division
of the incudostapedial articulation, by means of the angu-
lar knife carried into the joint from below upward and
cutting from behind forward against the pull of the sta-
pedius muscle. The release of the incus from its attach-
ment to the stapes allows the descending process to swing
outward and downward into view close to the long process
of the malleus. If this movement fails to take place, it
may be aided by means of the blunt hook, or the incus may
be at once extracted. By passing the angular knife be-
hind the tip of the long process of the malleus, above the
point of attachment of the tendon of the tensor tympani
muscle, and carrying it downward in contact with the
bone, the tendon is felt and divided, the complete cutting
of the tendon being usually made apparent by the in-
creased mobility of the malleus. The division of the
anterior and posterior striæ of the short process, which
next follows, leaves the malleus free from the attachments,
and makes it possible to determine how firmly it is held
in place by other means, and, if resistant to a light pull of
the forceps, the curved spatula knife should be passed
upward into the space above the short process and swept
backward and forward to divide adhesions and thickened
mucous reduplications which sometimes fasten the heads
of the larger ossicles firmly to the outer epitympanic
walls. To extract the malleus and incus simultaneously,

or to remove them individually, the loop of the wire snare should be drawn tightly about the descending processes, as high up as possible, the movement of withdrawal being downward and slightly from side to side, or they may be seized by a fixation forceps and extracted, in the same manner, singly. If completely freed from attachment, they easily come away; and that these attachments should be thoroughly cut, especially above the short process of the malleus, is important, because it is an evil experience, in removing that bone, to peel away the soft tissues from the tympanum or from the superior wall of the inner end of the auditory canal. Throughout the operation, alcohol on a cotton-tipped probe, and the extract of suprarenal capsule similarly applied, can be used with good effect in stilling hemorrhage.

In all middle-ear operations entailing hemorrhage, or distortion of the operative field by changes in position of movable parts, to have previously achieved a clear mental picture of the existent condition and of the various steps of the operation is eminently advisable.

After removal of the ossicles, the tympanum and epitympanum should be swabbed with the alcoholic solution of boric acid and then thoroughly dry-scrubbed by means of a cotton-tipped probe. The further examination should include careful tactile survey of the tympanic and epitympanic walls, and a determination of the condition and mobility of the stapes, necrotic spots should be curetted, adhesions in the fenestral niche divided, and if the stapes is otherwise free and can be utilized for sound transmission, either by membranous attachment or by the use of an artificial drumhead, the tendon of the stapedius muscle should be divided.

At the conclusion of operation the middle ear should be wiped dry and plugged with cotton, the canal walls then washed with sterile water by means of a cotton-tipped probe, and similarly scrubbed with alcohol, after which the cotton tampon in the tympanum should be removed and the canal filled with a sterile cotton wick; this dressing should be removed within forty-eight hours, under similar aseptic precautions.

When it has been possible to save the anterior portion of the drumhead and utilize it for closure of the tympanal end of the tympanopharyngeal tube, the middle ear should be packed with sections of sterile gauze tape from one to two centimeters in length, pressure being exerted upon the anterior flap to keep it in the position prepared for it, by curetting and dry-scrubbing the tympanic mucous membrane. The subsequent treatment, with or without the anterior flap, should consist in repetitions of the dry cleansing and packing until dermatization of the mucosa of the tympanic walls has been effected, or the tympanum has been closed externally by a cicatricial growth from the cut periphery of the drumhead.

TYMPANIC CURETTAGE

If the chronic suppurative disease is in progress, and there are present the redundant granulomata which almost

Fig. 25.—Middle-ear ring curette, general form. Full size.

invariably indicate the existence of areas of necrotic bone, such surfaces should be carefully sought for and curetted,

by means of the cup-shaped middle-ear or wire ring curette. Larger masses of granuloma, so-called polypi, protruding into the canal, should be removed by manipulation with the wire snare; evulsion must be avoided.

The common seats of limited necrosis in the epitympanum are the head of the malleus, the body of the incus, and the outer epitympanic walls. The thorough cleansing of the epitympanum, necessary to the satisfactory treatment of all cases of epitympanic disease and as an adjunct to surgical interference, is best effected by means of the middle-ear syringe

Fig. 26.—Middle-ear ring curettes, three sizes. Full size.

and the use of hydrogen dioxide; but as this remedy is, when used undiluted, distinctly irritating to the skin of some individuals, it is well to smear the canal walls lightly with vaseline. Limited curetting may be effectually done upon any accessible portion of the tympanic wall or ossicles, but should be carefully restricted to the diseased area.

REMOVAL OF EPITYMPANIC WALL

In the event of prolonged flow of pus from the superior-posterior portion of the tympanum which does not yield to careful curetting, lavage with hydrogen dioxide and astringent solutions and powder insufflations, larger access to the suppurative area than that already afforded by removal of the ossicles is desirable; this may be secured by removal of the posterior portion of the outer epitympanic wall, either through the canal or post-aurally.

The operation for removal of the posterior portion of the outer epitympanic wall through the external auditory canal is necessarily limited to those cases in which the

lumen of the canal is sufficient, and those in which there is no accompanying mastoid disease.

With the patient in a sitting or semiprone position, under full narcosis, after proper preliminary cleansing of the tympanic walls, an incision through the soft tissues of the canal, down to the bone, should be made lengthwise of the canal on its posterior-superior wall to the limit of the upward curve of the outer epitympanic wall, the resultant double flaps should be peeled outward by means of a middle-ear curette, bleeding checked, and the subjacent bone removed either by chiseling inward, with the long, slender canal gouge, or by working from within outward with a stout middle-ear curette or a rongeur; the formation and reflection of skin flaps is not a necessary part of this procedure, as both the slender chisel and the rongeur may be used directly through the soft tissues upon the bone.

The introduction of a protector, such as that used in the postaural operation for safeguarding the stapes, usually has to be dispensed with on account of the limited channel, a speculum in the hands of an assistant, through which the operation has to be done; but in using the canal gouge, a sufficient protection is afforded by a preliminary packing of the posterior epitympanic and adital space with tightly rolled pledgets of sterile cotton.

TYMPANO–ANTRAL EXENTERATION

The postauricular operation, consisting in an incision back of and close to the concha, a reflexion of the auricle and posterior-superior portion of the membranous canal and periosteum forward, and an oblique incision at the inner end of the canal, has the advantage of being appli-

cable in all cases and of affording a comparatively unobstructed field. After the preliminary incision and separation of the membranous canal and periosteum from the posterior-superior bony canal walls, the auricle with its connected soft tissues should be drawn and held forward by means of a long, narrow-bladed, angular retractor, thus revealing such portions of the membrana tympani and members of the ossicular chain as may be in place. If the anterior portion of the membrana vibrans is intact, it may be preserved for use as an anterior flap, the malleus being dissected out and extracted; if the head of the malleus and its articular connection with the incus is intact, the incudostapedial joint and the tendon of the stapedius muscle should be divided before extraction of the malleus, otherwise this may be deferred until the extraction of the incus following the opening of the epitympanum.

Preliminary to the removal of the outer epitympanic walls, a protector in the form of a narrow strip of copper, silver, or white metal, and bent nearly at a right angle at a distance of from three to five millimeters from its inner end, should be introduced through the canal, and carried into the epitympanum in such direction as to cover the stapes and inner adital wall, and should be held in position by an assistant. Another means for protection of the stapes and facial canal is the firm packing of the posterior portion of the tympanum, and of the aditus, with cotton pledgets. The external epitympanic wall should now be chiseled away, or removed by a rongeur, up to the level of the tegmen tympani, the removal being further extended backward into the antrum until the remaining portion of the posterior bony canal wall coincides

with the corresponding inferior wall of the aditus and the epitympanum, and the antrum and inner end of the external auditory canal are comprised in one cavity. The incus, together with all bone chips, should be removed, granulomata should be curetted, and the whole surface of the cavity dry-scrubbed as a preliminary to a careful examination of the tympanic, epitympanic, and antral walls. Areas which have been the seat of redundant granulomata, and spots of carious bone should be especially searched for and curetted, surfaces which have been the seat of cholesteatomatous accumulations should be bared, and the curetting carried through the presenting bony cortical walls into the diploë beneath, and the whole cavity surface again dry-scrubbed.

In the plastic portion of the operation (which has for its purpose dermatization of the mucosa of the resultant cavity walls), the longitudinal incision or incisions of the membranous canal, for the purpose of forming skin flaps, and the extent of their continuance outward into the cartilaginous portion of the canal, should be governed by the extent of the removal of the bony outer epitympanic and posterior canal walls, the end to be attained by the flaps being the creation of a dermal conjoined canal, antral and tympanic cavity. Where the external auditory canal is normally large, a single longitudinal incision posterior superiorly will usually suffice.

The incisions of the membranous portions of the canal for flap making should be made either with the narrow-bladed knife, through the lumen of the canal, cutting from within outward upon the retractor in the postaural opening, or by means of narrow-bladed straight scissors puncturing the membranous canal from behind and cutting

inward, upon a broad-grooved director or a flat metal
strip introduced into the canal.

With the extension of the longitudinal incisions out-
ward toward the concha, the cartilage should be dissected
out from the posterior surface of the flap, or pared away
by means of scissors, preliminary to closure of the post-
aural wound, during which the flap or flaps should be
pressed into and held in place upward and backward, and
ultimately kept in position by packing with small, counted
squares of gauze tape.

The after-dressings, at intervals of two or three days,
should consist in removal and replacement of the gauze
dressing, with such further dry-scrubbing, curetting, and
touching with alcohol and argentic nitrate solution as any
newly formed exuberant granulomata may require, and,
if dermatization demands it, additional skin graft.

The advantage pertaining to the use of a divided
packing in the tympanoantral and mastoidotympanal ex-
enteration is the possibility of more exact coaptation of
the dressing to an irregular surface, and the exercise of
pressure in varying degrees, either for the retention of
flaps or for the enhancement of dermatization; moderate
flattening pressure upon minute healthy granulomata abut-
ting upon a dermoid flap or skin graft tending to favor-
ably affect the extension of the dermatization.

The use of the simple sterilized, or of the iodoformed,
squares of gauze tape is a matter of the individual choice
of the surgeon, some surgeons having abandoned the use
of iodoformed dressings altogether, and others finding,
aside from antiseptic properties, value in a stimulating
effect on granulating tissue.

CHAPTER VII

MASTOID OPERATIONS

THE operation of opening the mastoid cavity for the purpose of evacuating its morbific contents, and removing also such portions of its cortical wall as may be diseased, is, in the majority of the cases to which it is applicable, a simple surgical procedure. It becomes complicated when the anatomical conditions are unusual, or when the diseased conditions are such as to require, in addition, removal of the bony posterior-superior canal wall and the outer epitympanic bony wall—mastoidotympanal exenteration—or extension of the operative field beyond the mastoid limits, either downward into the neck, upward into the middle cerebral fossa, inward and backward into the sinus and cerebellar fossa, backward superficially from the superior portion of the mastoid cavity, to include prolongation of pneumatic cells into the squamous portion of the temporal bone, or forward superficially into the root of the zygomatic process.

A study of the structure of the mastoid portion of the temporal bone, as well as of its relationship to the middle ear and to other important cavities in its neighborhood, explains the fact that they readily become a channel for the transmission of morbid processes originating in the middle ear, to those more deeply seated and important parts, invasion of which is liable to lead to serious and

possibly to fatal consequences. Considered as a whole, and aside from the fact that it is virtually a prolongation of the cavity of the middle ear, and that the lining membrane of its pneumatic cells is continuous with the lining membrane of that cavity, and so affords an area of vascular tissue subject to congestion and inflammation manifoldly greater than that afforded by the middle ear alone, the internal structure of the mastoid itself, in regard to its subdivisions, is such as to render possible considerable differences in the symptoms characterizing an inflammation within its walls.

The great variations in the contour and in the thickness of the cortical wall of the mastoid, coupled with uncertainty as to the changes effected by disease and the necessity in that respect of subjecting the inner cortical wall to careful examination, emphasizes the importance, in any mastoid operation, of making a large opening through the outer mastoid cortex.

The diseases of the mastoid which are the most frequent, and also the most important from a surgical point of view, are the acute congestions and inflammations secondary to similar processes in the middle ear.

A careful study of the few cases of reported primary mastoid inflammation on record suggests, in the light of more recent experience in this field of clinical investigation, the suspicion that there had been previous middle-ear inflammation as the inceptor of a chronic quiescent mastoid disease, which was later awakened to acute manifestations, while in others the implication of the mastoid cells possibly followed a superficial periostitis on the outer mastoid surface, with pus formation, denudation of bone, and subsequent spontaneous perforation inward.

In the cases, comparatively rare, of invasion of the mastoid cavity from the external auditory canal, following and consequent upon an otitis externa diffusa or an otitis externa circumscripta of the posterior wall of the bony canal, the progress of events is a superficial, circumscribed periostitis, with death of the underlying cortical bone and of the contiguous cell walls, the limitation of the process being accompanied by a circumjacent engorgement and swelling of the lining membrane, similar to that occurring on a larger scale in the mastoid antrum in the event of extension of inflammation from the middle ear. This swelling, which plays a part in the isolation of the inflamed region, serves also to favor the subsequent separation of the resultant sequestrum, and in this class of cases of circumscribed mastoid disease the removal of a mass of separated bone from the posterior wall of the canal, either by spontaneous extrusion or by surgical procedure, reveals a limited cavity, which rapidly fills in with granulation tissue. The sequestrum is usually characteristic in exhibiting a smooth wall on one side and cancellated bony tissue on the other. The common starting point of this inflammation, and the part usually included in the sequestrum, therefore, is that portion of the posterior wall of the external auditory canal at or near the outer limit of the osseous canal proper, the sequestrum consisting of a small portion of the superficial cortex with attached portions of the underlying cell walls.

MASTOIDECTOMY

The operative opening of the mastoid process, though it has to deal with the liberation of pus and the removal

of the contents of a septic cavity, should be done under aseptic conditions.

If possible, twelve hours or more before operation, the supra- and postaural regions should be shaved, carefully scrubbed with soap and water, washed with clear water, rubbed with alcohol, and covered with a sterile dressing, which should remain in position until the time of operation. The ear itself should be carefully syringed, or otherwise cleansed, and stopped with a pledget of cotton or sterile gauze, and this procedure should be repeated immediately before the operation.

After etherization, which should be carried to full narcosis, the ear should be examined, and if the opening in the membrana tympani is small and insufficient for drainage it should be enlarged, or else a crescentic peripheral cut, similar to that for exploratory tympanotomy, should be made, and granulation tissue or polypi should be removed.

In cases of long-continued suppurative middle-ear disease the preliminary operation in the middle ear may of necessity include removal of carious ossicles, and such other manipulations as are required to insure surgical cleanliness, and cultures may advisably be made from the fluid in the middle ear as well as from the mastoid contents.[1]

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[1] To determine the character and course of infection, cultures carefully made in a series of mastoid operations gave the following percentages:

Streptococcus was found pure in thirty-four per cent; staphylococcus, in thirteen per cent; diplococcus, in seventeen per cent; streptococcus and diplococcus were found in seventeen per cent; streptococcus and Bacillus fœtidus, in nine per cent; streptococcus and Bacillus pyocyaneus, in two per cent; streptococcus, staphylococcus, and diplococcus, in five per cent.

As a rule, the same germ obtained by paracentesis of the drumhead in the early stages of the infection of the middle ear was found later in the mastoid.

The operation in the middle ear having been completed, the canal should be plugged with a strip of sterile gauze, the sterile dressing above and behind the ear should be removed, and the hair covered by a rubber cap or a sterile towel tightly pinned.

A sheet of rubber tissue should be spread over the shoulders of the patient, fastened about the neck, and covered with a sterile towel; sterile towels should also be spread over any surfaces with which the instruments and hands of the surgeon and his assistants may possibly come in contact; or a sterile sheet, with an opening in it large enough to expose the field of operation, may be extended over the head of the patient, sufficiently far forward, supported by a light framework attached to the operating table, to inclose the etherizer and the face of the patient from the operative field. The patient should be in a recumbent position, and so placed upon the operating table as to make the mastoid region easy of access under good general illumination, provision for special illumination of the interior of the mastoid being provided by means of a reflecting mirror or the electric photophore.

The instruments commonly required for the simple mastoid operation should be boiled in soda solution, and ranged in order upon a table previously covered with a sterile towel, and should include one or more scalpels, retractors, either hand or self-retaining, a periosteum scraper, a mallet, a small rectangular probe, grooved

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In one case cultures from paracentesis gave staphylococcus and diplococcus, while from the mastoid, at the time of operation, several days later, a pure culture of diplococcus was obtained; thus showing that the germ in the middle ear was, to commence with, diplococcus, which affected the mastoid, the middle ear later on becoming infected with streptococcus also.
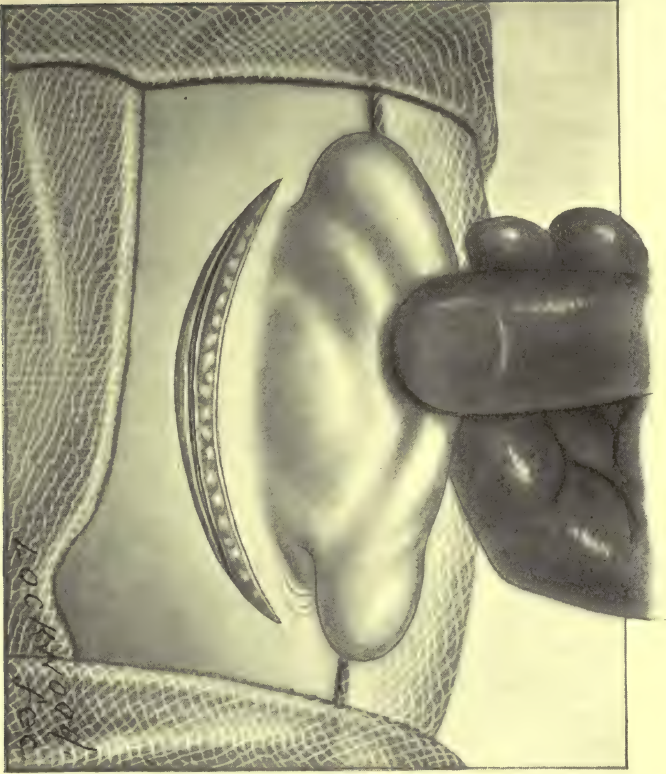
PLATE G.—Preliminary Incision in Soft Tissues, for Mastoidectomy.

directors, chisels, gouges, and curettes, according to the preference of the operator, one or more malleable probes, scissors, straight forceps for handling sponges and dressings, and nippers for controlling hemorrhage from the flap.

The sponges should be pads or squares of sterilized gauze, and, for use within the mastoid cavity, should preferably be from one to two centimeters in length, one centimeter or less in width, and so folded as to afford a thick body and thin edges. Sponges of Griswoldville gauze of these dimensions, folded with all edges inside, should be used entire without unfolding, and are much better, both because of their absorptive properties and for convenience in handling, than larger sponges made of ordinary gauze.

The preliminary incision through the soft tissues should be, preferably, curvilinear, extending from a point above the superior border of the concha to or below the tip of the mastoid. (Plate G.) In case of extension of pus from the mastoid process through the digastric fossa or mastoid tip downward into the tissues of the neck, the cut should be extended in a corresponding direction; while in the event of pneumatic cells prolonging the mastoid cavity backward, or into the base of the zygoma forward, it may be supplemented by incisions in these directions.

In the majority of cases it is best to enter with the knife vertically at the upper end of the incision, carrying it downward to the bone, and so continuing throughout the whole length of the cut, deviations from this rule, both as to direction and manner of cutting, being made in cases of subperiosteal postaural abscess, where it is necessary

to include the abscess cavity in the primal or in a divergent incision.

Where the periosteum is not divided thoroughly at the first cut, the incision should be repeated until this has been effected, and the periosteum should then be retracted.

The bleeding from the soft tissues varies very much in individual cases, but is easily controlled by the use of nippers, which may be left attached during the remainder
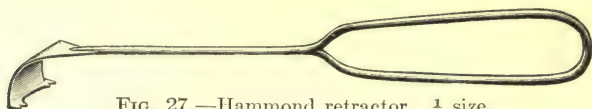
Fig. 27.—Hammond retractor. ¼ size.

of the operation, if necessary, by the use of broad-bladed retractors (Fig. 27), and, in the cases of prolonged seepage from œdematous tissues, by sponging with hot water.

The edges of the wound being spread apart by means of retractors and the bone sponged dry, careful inspection should be made to determine the position of the external auditory canal, the meatal spine, and the contour of the mastoid surface, and also to detect any points of congested or diseased bone in the cortex. (Plate H.) The operative field should be again dry-scrubbed with sterile gauze sponges, and seepage of blood upon it having been controlled, the opening of the mastoid cavity may be entered upon.

The first opening in the cortex may be made either with the gouge or the chisel, and should in all cases be large enough to admit of free access to the mastoid cavity, preferably including the major part of the outer mastoid cortex, to the extent of permitting free visual as well as tactile examination of all of the remaining cortical walls, and free access to the antrum and to the mastoid tip.
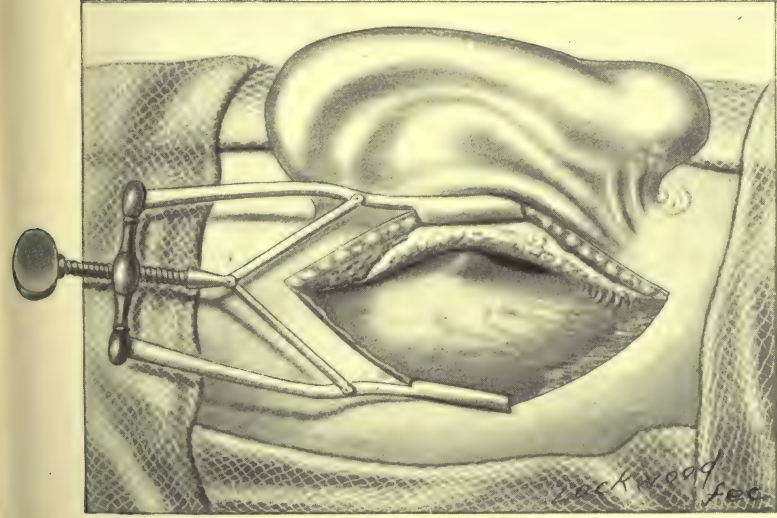
PLATE II.—Surface of Mastoid Process exposed; Periosteum and Soft Tissues retracted by Self-retaining Instrument. Supra-meatal Spine, External Auditory Meatus, and Tendinous Attachment of Sternocleidomastoid Muscle clearly depicted.
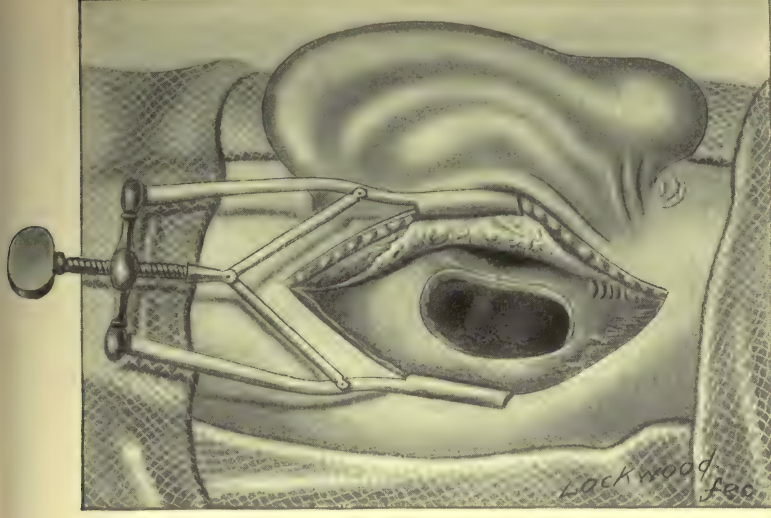
PLATE I.—Simple Mastoidectomy; the Antrum and Tip Cell exposed to View. From these Points the Operation may be extended in any Direction as Far as Necessary for the Removal of Diseased Tissue.

Access to the mastoid cavity through a large external opening having been secured, the next step, evacuation of its contents, is to be effected by means of smaller gouges or chisels (Fig. 28), or by the use of curettes—the chisels
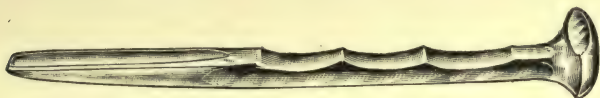
FIG. 28.—Mastoid chisel. ¾ size.

for hard and dense bone, the curettes for softer or more disintegrated bone, and for removal of granulomata and bone detritus. The sharp spoons can be used not only in rotation, but for extraction as well, and being provided with an elongated, round-backed bowl and a projecting tip, are efficient instruments for working from within outward.

FIG. 29.—Mastoid spoon. ¼ size.

With a long-handled spoon (Figs. 29 and 30) of this shape it is possible to clear the mastoid cavity and mastoid antrum completely of all granulation tissue and bony detritus, without the dangers incident to the rotary use of a circular spoon, or the incisive effect, from without inward, of the chisel and gouge. With
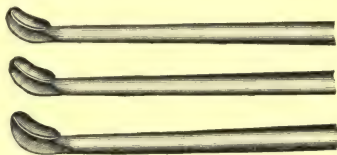
FIG. 30.—Bowls of mastoid spoons.
Full size.

such a spoon also it is possible, when necessary, to remove the diseased inner cortical wall, to push the dura back with the rounded bowl of the spoon, and, working from within outward, with the sharp tip to remove the thinner bone with facility, and even, in cases of hemorrhage from

the sinus, to so rapidly enlarge the cortical opening as to allow the pressure of the brain itself, flattening the vessel against the bony edge of the opening, to effectively stop the hemorrhage, and allow the operation of evacuation of the mastoid to continue uninterrupted by the necessity for plugging.

Bimanually used, the long-handled, long-bowled spoon is an exploratory as well as an operating instrument. The spoons, or curettes, are unfenestrated, and made with a stout shank and sharp cutting edge to the bowl, which is, moreover, extended in a curved lip, permitting the passage of the spoon behind spiculæ or thin pieces of bone or sequestræ, and effecting their removal by its withdrawal. In the event, also, of an opening in the inner mastoid wall, a sharp spoon with its rounded bowl and projecting tip becomes a valuable instrument, since it may be used to work from within outward with the least danger to important soft tissues; the handle of the spoon may advantageously be gouged, or otherwise marked, by some smooth variation of its surface on the side toward the cutting edge of the bowl, the hand of the operator being thus constantly apprised of the direction of the cutting edge of his instrument. This method of roughening the handle of cutting instruments which are to be used beneath the surface, and therefore under governance of touch, has the additional advantage of affording a firm grasp of an otherwise smooth surface, and of doing this without providing such opportunity for the lodgment of septic material as is afforded by fine serrations. The handles of all the instruments used should be of metal, smooth finished, and preferably with a smooth, gouged, or undulating surface, in place of the usual serrations.

The first step after evacuation of the mastoid cavity having been the clearing of the mastoid antrum, attention should next be directed to its central and anterior portions, to the tip, and finally to the superior and posterior walls, the cortical opening being extended, when necessary, inferiorly to include the whole of the tip, and posteriorly and superiorly to the extent of entirely revealing the mastoid cavity, and such pneumatic cells as are sometimes found extending backward to the limit of the temporal bone.   (Plate I.)

Gauze sponges should be used during the operation within the mastoid and at its completion, for the purpose of thoroughly dry-cleansing the cavity, which can then be subjected to a careful examination, both ocular and tactile, for the detection of any diseased bone or granulation tissue pocketed in some irregularity of the inner mastoid surface.

COMPLETION OF MASTOIDECTOMY.—For the simple mastoid operation the formation of such set rules as the removal of the entire mastoid tip and extension of the operation to include the root of the zygoma, in all cases, is objectionable on the ground of its possible superfluity. The opening of the mastoid cavity, by removal of its outer cortical wall, should be so large as to permit thorough visual as well as tactile investigation, and experience has shown that, in the majority of the cases thus dealt with, the whole or the greater part of the mastoid tip may be left intact, and that the cells in the root of the zygomatic process are rarely involved.   The advisable sequence of procedure, in the simple mastoid operation after removal of the outer cortex and evacuation of the main portion of the mastoid cavity, may be briefly stated,

as, first, establishment of free communication with the antrum and middle ear; second, free evacuation of the mastoid tip; and, third, curetting of the posterior portion of the mastoid, removal of diseased portions of the inner cortex, and exposure of the sinus. The true conservatism in the mastoid operation is that which is most radical in the removal of all diseased, and most judicious in its conservation of all really sound tissues.

While the simple mastoid operation has for its main purpose the removal of the contents of a cellular cavity, the walls of which are mainly formed of firm cortical bone, the possible necessity for removal of portions of the inner cortical wall should always be had in mind, and, after the main evacuation has been accomplished, the exposed inner cortex should be subjected to careful search for any points of reddened bone, or of any opening of adventitious cells requiring further removal.

Blood-clot Dressing.—Bleeding bone should again be curetted until a firm, hard surface has been reached, or the bone entirely removed exposing the subjacent soft tissue, whether muscle or dura, the purpose of the operation being to produce as nearly as possible a dry aseptic cavity, which may then be allowed to fill in with blood from the surrounding soft tissues.

At the close of the operation the resultant bone cavity should be packed with small gauze sponges, and attention directed to the soft tissues. The retractors and nippers being removed, areas of necrotic soft tissue should be searched for and curetted, or otherwise eliminated, together with all loose shreds; the clean surfaces of the mastoid wound should then be refreshed by curetting, their bleeding filling the mastoid cavity, from which the
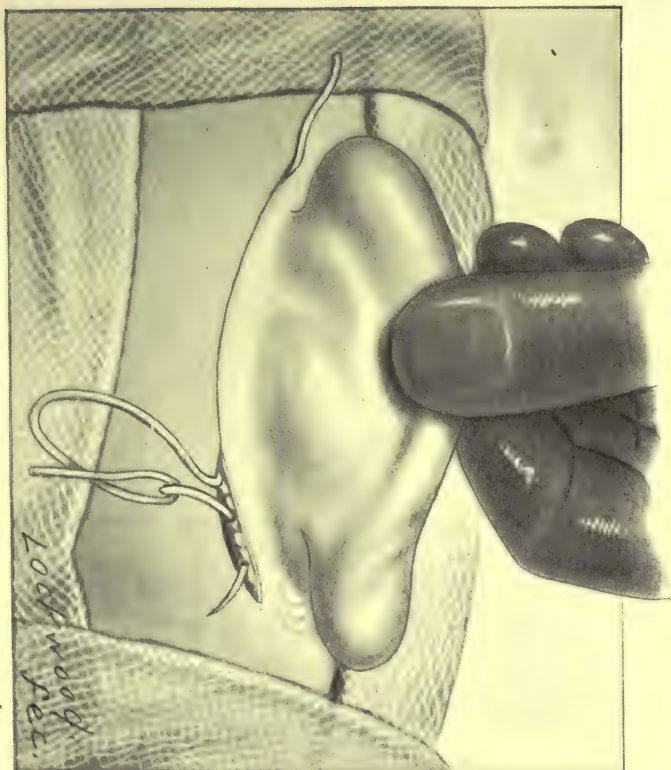
PLATE J.—Showing completed Mastoid Operation. Bone Cavity filled with Blood Clot and the Wound closed by Subcutaneous Silver-Wire Suture.

sponges have now been removed, and the cut surfaces should be brought into apposition and so maintained either by pressure pads or by sutures, the final application being the usual dry sterile dressings and bandages.

In the majority of instances, where the preliminary incision has been simple, and carefully made, coaptation of the cut edges by pressure pads is sufficient for satisfactory healing. With an inclined or an extended cut the coaptation under pressure may need to be supplemented by single, interrupted sutures, of silk or silkworm gut, while for complete sutural closure the continuous subcutaneous silver-wire suture is the best. (Plate J.)

Unless otherwise indicated, by pain, rise in temperature, or discharge from the wound, the dressings may be left in place for five days or more, when, if asepsis has been perfect, the wound will be found to have healed by first intention.

Experience with the blood-clot method of mastoid dressing shows that healing by first intention, with subsequent persistently good results, is obtainable in a sufficiently large proportion of cases, both acute and chronic, to make its attempt as an ordinary procedure justifiable.[1]

Of danger by this method there is apparently none, since, in the event of failure to organize, the clot breaks down, usually either wholly or in part, within forty-eight hours, in proportion to the extent of the infection, and

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[1] Tests with the blood-clot dressing in a series of services at the Massachusetts Charitable Eye and Ear Infirmary, applying it in all cases without reference to the systemic condition of the patient or character or extent of the local disease and requisite surgical interference, gave proportions of primary healing varying from twelve to fifteen per cent ; while the same tests applied in selected cases of good systemic condition and comparatively acute mastoid involvement gave primary healing in from fifty to seventy-five per cent.

there results the condition of an open wound healing by granulation tissue, and to be treated by the usual method of packing and cleansing. In some instances the blood clot organizes and remains firm in the upper portion of the mastoid wound, while drainage from the antrum is effected below through a broken-down portion of the clot, forming a sinus that subsequently heals by granulation. If, therefore, for any reason, systemic or local, it seems inadvisable to adventure the blood-clot dressing entire, a sterile gauze wick may be inserted into the antrum, or the whole cavity may be lightly packed with sterile gauze, with a view to the slower process of healing by granulation.

Under these circumstances, the objection to the superficial closure of a wound incident to an operation having for its purpose the evacuation of a septic cavity has less force, and by the blood-clot dressing an opportunity is given for the progress of a natural reparative process at first hand, either throughout the whole mastoid cavity or in part, while, even in the event of complete disintegration of the clot, an impulse has been given to the formation of healthy granulation tissue.

It is, of course, to be understood that where the conditions at the time of operation are such as to make postoperative access to the parts desirable, the blood-clot dressing is inadvisable.

COMPLICATIONS.—The complications of mastoid disease which may require surgical interference, beyond the boundaries of the mastoid region, and which, on account of their intimate and consequent connection with it, must of necessity come within the province of the aural surgeon, are those which attend the extension of the mastoid

inflammation, or of its products, either downward into the tissues of the neck, upward, subcutaneously, as in the formation of the post- and supra-aural abscesses, and inward or upward into the cranial cavity, or into the sinus.

CERVICAL ABSCESSES

In the great majority of cases of burrowing of pus from the mastoid cavity into the tissues of the neck there is found to be the not uncommon combination of a thick mastoid cortex on the outer surface, with thin bone at the tip, and in the digastric fossa, from which point the direction taken by the pus, in gravitating downward, is governed both by location of point of exit and the guidance of the muscles and fascia; pus issuing from the tip of the mastoid usually making its way downward along the line of the sterno-cleido-mastoid muscle posteriorly thereto and sometimes passing forward into the anterior triangle, while pus making its exit at the digastric fossa usually extends backward under the deep fascia and follows down the back of the neck, unless its cumulative pressure forces its way through one of the fascial lacunæ outward, into the anterior portion of the posterior triangle.

One of the marked evidences of a spontaneous perforation of the mastoid cortex is a cessation of the painful symptoms in the mastoid, with or without corresponding decrease of temperature, and, simultaneously or subsequently, evidence of the point at which the pus has made its exit, as shown by swelling or tumefaction of the adjacent soft tissues.

In the event of swelling over the digastric fossa, tenderness at this point upon deep pressure, and other evidences both of involvement of the mastoid tip and of

presence of pus in the neck, the operative incision, beginning as usual on the upper part of the mastoid surface, should be carried downward and backward posteriorly to the mastoid point of insertion of the sterno-cleido-mastoid muscle, and downward into the neck, as far as may be requisite to secure thorough drainage.

At the conclusion of the mastoid operation the sinus opening into the neck should be thoroughly dilated, and search made within the mastoid cavity for other possible points of exit downward, suspected areas of the mastoid cortex at the tip being completely curetted, or the entire lower portion of the mastoid removed, if necessary.

The dilated sinus into the neck being carefully explored by means of a long blunt probe, its lower limit determined, and a counter opening made, if necessary, the sinus, and such portions of the mastoid cavity as are not allowed to fill in with blood clot, should be packed with sterile gauze or iodoform dressing, or a rubber drainage tube inserted, and bandaged in the usual manner.

The subsequent dressing of a sinus of this description, without external opening at its lower extremity, should include removal of all detritus, thorough cleansing, and apposition of its walls by pressure applied from below upward.

For cleansing purposes, the use of the hydrogen dioxide is a valuable addition to other treatment, the precaution always being taken to insure a free egress of the resultant pressure at the upper portion of the sinus.

If, at the time of operation, the pus has already pointed, or gives indication of so doing, in the lower part of the neck, the mastoid incision should be continued to a point sufficiently below the mastoid tip to permit of the

bone being reached from below as well as above, with a view to its entire removal, if needed, and to permit easy access to the channel along which the pus has made its way, after its exit from the mastoid cavity.

The course of the pus downward in one or more directions, and the limit to which it has gravitated, having been determined by the use of the long malleable blunt-ended probe, an incision should be made into the neck at the bottom of the sinus, the cutting being done either upon a probe or director or upon the finger, introduced into the pus cavity from the wound above.

Openings having been thus established at the two ends of the sinus, its walls should be lightly curetted, and either a fenestrated drainage tube or the gauze wick packing inserted, subsequent dressings consisting in renewal of these applications, and syringing with either normal salt solution or hydrogen dioxide, until the sinus closes.

In the more extensive burrowing of pus in the tissues of the neck it is occasionally necessary to lay the sinus open throughout its length, which should be done either by cutting outward from a grooved director, where the sinus is superficial, or by an incision from without inward, through the successive layers of skin, muscle, and fascia, where it is deep.

In that type of temporal bone in which the projection of the mastoid process presents in its lower third the form of a nipple, a spontaneous perforation of the cortex, and exit of pus, may occur on the inner side, and the pus, finding its way along the inner surface of the sterno-cleido-mastoid muscle, may burrow into the deep tissues of the neck extensively before giving external evidences of its presence, the ultimate pointing being usually ante-

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riorly to the muscle in its lower third, or posteriorly at a corresponding level toward the median line. Where this has already occurred when the case comes to operation, the mastoid tip should be thoroughly searched for this and other possible points of exit, and either entirely removed, or, if its cortical substance is firm and healthy except in the region of perforation, the extremity of the tip should be removed, by chisel or rongeur, from without inward, until the perforation and surrounding area of bone are included in a longitudinal opening, widening from the point of spontaneous perforation outward, the purpose being not only to remove all infected bone, but to provide free access to the deep-seated sinus from above.

POSTAURAL ABSCESS

Spontaneous perforation of the mastoid cortex either into the external auditory canal or on the upper portion of the outer mastoid surface, and the formation of the so-called postaural abscess, occurs more frequently in young children than in adults, as would be expected from the character of the bone; but in neglected cases of suppurative mastoid disease in adults, large accumulations of pus are sometimes found extending backward from the upper border of the mastoid process, the explanation of the exit of pus from the mastoid cavity at this point being found either in the thinning of the bony wall, the passage outward along the course of a vessel, or the presence of large pneumatic cells which prolong the mastoid cavity, in its upper portion, to an unusual distance backward, and which usually have thin exterior bony walls.

In these cases the usual incision through the soft tissues should be made to include the superficial pus cavity,

or should be supplemented by a divergent incision laying the pus cavity sufficiently open to permit of the thorough cleansing of its walls and the search for the point of exit of the pus from the mastoid, and for any area of necrotic bone.

Areas of necrotic bone should be thoroughly curetted, or removed by means of the chisel, gouge, or curette, until only sound bone remains, and the opening through which the pus has found exit should be made the starting point for a free removal of the cortex, until the pneumatic cells are laid open to the extent of including them in the general opening of the mastoid cavity.

Previous to the general mastoid operation the walls of the superficial pus cavity should be thoroughly curetted and dry-scrubbed, and subsequently the walls should be brought into apposition by pressure pads, or the cavity dressed with sterile or iodoform gauze, as the extent of the superficial cavity or the degree of necrosis of its walls may indicate.

MASTOIDOTYMPANAL EXENTERATION

When spontaneous perforation of the cortex has occurred, as on the anterior mastoid cortex, forming the posterior canal wall, this bone should be removed, to inclusion of the point of spontaneous perforation, and prolonged, in cases of more extensive disease of the bone and of cholesteatomatous accumulation in the antrum and epitympanum to include entire removal of the postero-superior portion of the bony external auditory canal and outer epitympanic wall, constituting the mastoidotympanal exenteration.

The essential steps of this operation include removal

of the posterior portion of the superior canal wall, including the posterior portion of the outer epitympanic wall and the superior portion of the posterior bony canal wall, by means of the chisel or rongeur, the removal of morbific contents of the tympanic cavity, including diseased ossicles, careful examination of the epitympanic and antral walls, with removal of such portions as may be diseased, and, finally, such provision for postoperative access to the field of operation as the circumstances of the case require, either by the establishment of a permanent postaural opening with dermal walls created by skin flaps or by skin grafting, or a combination of flap and graft, or by enlargement of the auditory canal and primal closure of the posterior opening.

Having completed the mastoid operation proper, the retractors should be removed from the postaural wound, the auricle pulled forward, the soft tissues of the external auditory canal carefully separated from the superior and posterior bony canal wall, complete separation being insured by an incision through the soft tissues at the inner end of the canal posteriorly and superiorly, and the auricle and soft tissues of the canal drawn and held forward by means of a broad band of stout tape or of folded gauze passed into the canal posteriorly, drawn out through the meatus, and its two ends held by an assistant, or by means of a long narrow-bladed rectangular retractor inserted posteriorly for the same purpose. (Plate K.)

With the field thus cleared, the removal of the bony canal and epitympanic wall may be easily effected by means of the chisel or rongeur, as may be preferred. In the use of the chisel the cutting should be carried above, directly inward and forward, while below it should be
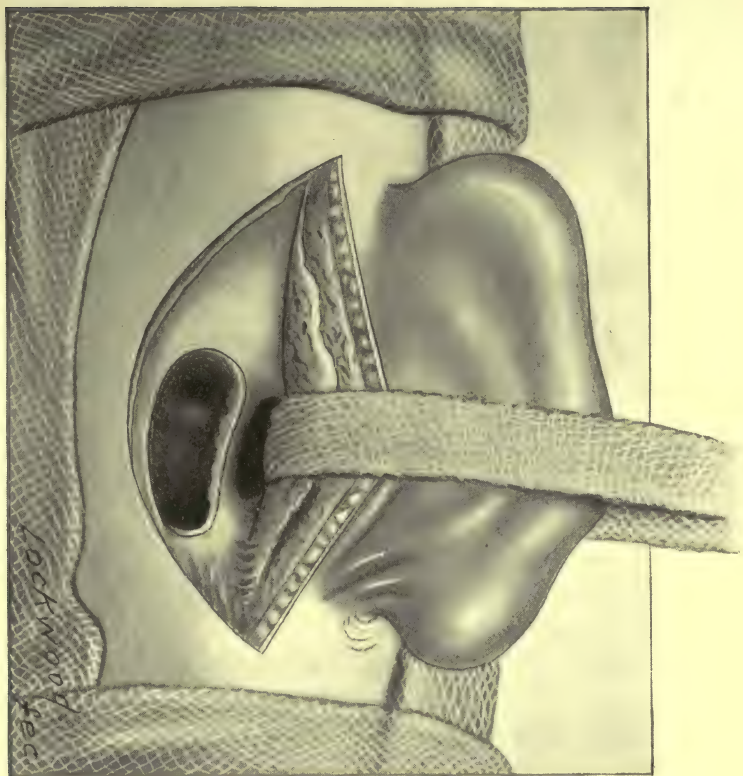
PLATE K.—Auricle drawn Forward by Gauze Strip, preliminary to Removal of the Postero-superior Wall of the Canal in Mastoido-tympanal Exenteration.

carried upward at such an angle as to avoid at its inner end the antral floor, and thus safeguard the canal of the facial nerve, which in some cases runs superficially beneath the inferior antral wall, its position marked by a well-defined hard bony ridge.

The lines of bone incision present the sides of a rectangular triangle, the superior side being nearly horizontal, from without inward, and the inferior trending toward it at an agle of 45° and terminating in the epitympanum and aditus ad antrum mastoideum. (Plate L.) In the depth of the cavity thus exenterated may be seen, if *in situ*, the two major ossicles, showing plainly against the dark background by means of their contrasting whiteness.

The removal of these bones is merely a matter of careful dissection of their normal or pathological attachments, and the separation of the malleus from the anterior portion of the drumhead, which, if intact, may be utilized for an attempt at closure of the tympanic orifice of the tympanopharyngeal tube, by curettage of the tympanal mucous membrane and subsequent packing of the drumhead flap forward.

The mastoidotympanal exenteration should include not only removal of the two major ossicles, whether themselves diseased or not, in order to secure free access to the epitympanic space for subsequent dressing, but access to the aditus ad antrum should be secured, if dressings are to be done through the external auditory canal, by slitting the membranous canal either superiorly or supero-posteriorly, and also posteriorly or postero-inferiorly, as far out as the concha, the flap thus formed being denuded of its cartilage by shaving its posterior surface

with a scalpel, or paring it with curved scissors, preparatory to packing it upward and backward into the antrum, and closing the postaural wound permanently at time of operation.

During the closure of the posterior wound this canal flap should be held firmly backward by means of a canal retractor, a broad sound, or other convenient instrument which will keep it in its assigned place until its position there is secured by means of packing introduced into the canal. This packing should consist of small pieces of broad gauze tape, plain or iodoformed, as may be preferred, not more than an inch in length, introduced by means of an angular dressing forceps, under good illumination, through the now widened canal, and counted as they are put in place. Before their introduction the middle ear should be carefully mopped and dry-scrubbed by means of a sterile cotton-tipped probe, and the whole procedure of dressing should be conducted under the aseptic precautions proper to any operation.

Especially if it has been possible to conserve the anterior portion of the drumhead, the first pack should be made in the direction of pushing this upward and forward, care being taken to insure its sufficient peripheral division, on its anterior border, to make its movement in this direction possible; the further packing in the tympanum should be comparatively light, and in the canal, from within outward, increasingly firm enough to keep the canal flap in place.

The postaural wound having been previously closed by the interrupted or continuous subcutaneous suture, the usual dry gauze dressing and bandage should be applied. A dressing of this kind, in a case of searchingly
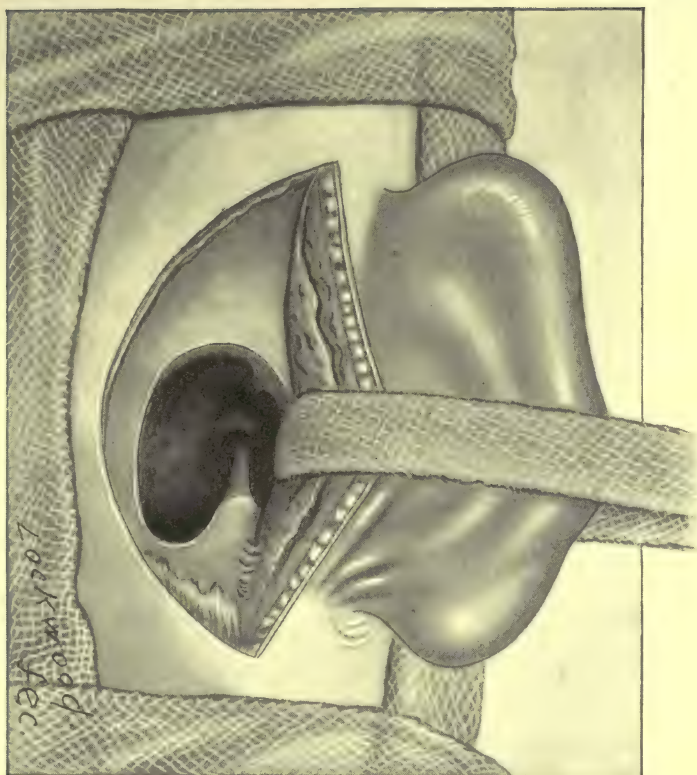
PLATE L.—Complete Mastoido-tympanal Exenteration.

examined and completely evacuated tympanomastoid ex-
enteration, may, except for untoward general conditions,
be advisedly left in place for four days and then exam-
ined, with removal of the canal and middle-ear packing,
in reference to the advisability of skin grafting for fur-
therance of dermatization.

In a completely radically effective operation the pos-
terior wound will be found, at this first dressing, to have
become closed, with exception of its lower end, through
which there is a serous seepage from the organizing clot
within, and the removal of the canal packing will show
the canal flap in place and the tympanic mucosa in con-
dition for skin grafting, or already showing first evidences
of dermatization, in which latter case the packing may be
removed or lightly renewed.

The objective indications of a spontaneous dermatiza-
tion, or of fitness for skin grafting, are shown in a still
reddened, but smooth and nearly dry, tympanic mem-
branous lining and a healthy postaural wound with agglu-
tinated edges. The skin grafting should be done by the
Thiersch method, the grafts being carefully apposed to
the tympanic wall, without rolled or loose edges, smoothed
and pressed into place by means of a dry cotton-tipped
probe, and then retained by the light pressure of small
sections of gauze tape, as in the first dressing. The util-
ization of the anterior portion of the drumhead as a flap
over the opening of the tympanopharyngeal tube, where
this is possible, materially facilitates the process of re-
pair, both by shutting off a channel for further possible
infection and by furnishing a starting point for spon-
taneous dermatization. Where this use of the anterior
portion of the drumhead is not possible, either because

it is wanting as the result of disease, has been removed at time of operation, or is inadequate in size, the tympanic end of the tube should be lightly curetted, dry-scrubbed, and the attempt made to close off the tubal opening from the middle ear by means of a skin graft.

The success of this method of operation, consisting in radical evacuation and in primary closure of the post-aural wound, has made it possible to avoid, in the great majority of cases, the protracted and often painful after-treatment incident to the establishment of a permanent postaural opening, but the success implies, as a necessity, a searching and careful operation and the complete removal of all diseased tissue.

PERMANENT POSTAURAL OPENING

In tuberculous, luetic, or diabetic subjects, and particularly in children, in whom the quality of the bone renders it especially liable to a secondary extension of an osteomyelitis, the maintenance of the postaural opening, until it has become filled by gradual healthy granulomatous growth from within outward, or has been constituted a permanent opening by dermatization, is more frequently necessary; but the great majority of cases requiring tympanomastoid exenteration may be brought to a much more speedy and satisfactory termination by careful operation, closure of the posterior wound, and subsequent dressing through the enlarged external auditory canal.

The establishment of a permanent postaural opening, in cases of tympanomastoid exenteration, has for its purpose not merely continued access to the field of operation, but the ultimate substitution of a protective dermoid tissue for the mucous lining. The achievement of this latter

end entails prolonged and often painful treatment, and
ultimately, in many cases, the performance of a plastic
operation to close the established postaural opening.

Where the establishment of a permanent postaural
opening, with dermatization of the mastoid, antral, epi-
tympanic and tympanic walls is desired, the creation of
a dermal tube from behind, inward, forward, and out-
ward, to join the skin lining of the external auditory
canal, is favored by the formation and apposition of skin
flaps taken from the less pilate portions, or by the transla-
tion of skin into the wound. Narrow flaps may be taken
from the posterior surface of the auricle, from the adja-
cent region of the neck, and from the posterior mastoid
surface, within the hair line, such flaps consisting only of
the superficial dermis and a thin layer of subdermal tis-
sue, with a narrow attachment to the main body of the
skin sufficient for circulatory nourishment, but permitting
the flap to be easily turned into the postaural cavity.

Translation of skin into the postaural wound may be
effected by dissecting up the subdermal layer from the
edge of the wound, in any desired direction in a direct
line, to the extent of one or more centimeters, making a
superficial incision at the termination of this line of dis-
section and at right angles to it, slipping the separated
skin into the postaural wound, and closing the temporary
superficial incision by still further dissection of the sub-
dermal layer beyond it, and slipping that forward and
uniting the two cut edges by sutures. The skin transla-
tion, where it is feasible, has the advantage of supplying
a well-nourished and comparatively epilate surface favor-
able to the extension of dermatization. The skin flaps, or
skin translation, should be kept in contact with the sur-

faces to which they are applied by the introduction of firm gauze packing, either plain or iodoformed, which should be kept in place without redressing, until the flaps or translations have become firmly adherent, unless symptoms of deeper seated trouble supervene, in which case the packing should be removed with careful consideration of the attachment of the underlying skin, a care which is more easily exercised if divided packing is used. In some cases the periosteum, carefully dissected up and conserved during operation, may be used to supplement the skin reflexions.

<center>EXPLORATION OF THE LABYRINTH</center>

Opening of the labyrinth is always performed secondary to a complete mastoidotympanal exenteration. The outer epitympanic wall and the cortex external to and above the antrum should be completely removed in order to secure the most satisfactory exposure of the inner walls of the tympanum, aditus, and antrum. Entrance to the superior semicircular canal may be gained at a point directly above the oval window and about six millimeters therefrom. The projection of the canal for the facial nerve passes horizontally, antero-posteriorly, between the oval window and this semicircular canal, the average distance from the fenestrum being three millimeters. The greatest care must be exercised to prevent injury to the facial canal, for if the nerve is naturally exposed, or if an instrument should accidentally penetrate its coat, the nerve is liable to injury, and the surgeon will be confronted later by a facial paralysis as an unpleasant consequence. Bourguet [1] has devised a special instrument for

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[1] See Appendix, note No. 8.

the protection of the facial canal during an opening of the semicircular canals, and the schematic drawings accompanying his article illustrate very well the several steps of the operation for complete labyrinth exposure.

A narrow chisel is the best instrument for removing the bone covering the canals, and the opening into the superior canal can be extended posteriorly, in the shape of a narrow gutter, to join the external or horizontal canal. Entrance to the vestibule is most readily gained by removing the foot plate of the stapes. When this ossicle is present as a whole it may be grasped by forceps, or a hook passed between its cruræ, and extracted by gentle manipulation. If it is anchylosed, the chisel or gouge must be employed for its removal. Having thoroughly opened the canals and established communication with the vestibule, the operation may be completed by removal of the promontory anteriorly and interiorly to the level of the tympanic orifice of the tympanopharyngeal tube and posteriorly to a junction with the round window. When the opening into the cochlea is made through the round window care should be taken not to penetrate too deeply, lest the carotid artery, which may be in close proximity, shall be wounded.

During all of these procedures a good illumination of the operative field should be maintained. An electric headlight may be worn for this purpose, or a strong reflector employed to concentrate the light where it is needed.

EXTRADURAL ABSCESS

The sequence of extension of a septic inflammatory process from the middle ear to the mastoid cavity is, first, through the connecting pneumatic cells, extending thence

to the surrounding diploë, and, finally, to such portions of the mastoid cortex as may be more vulnerable, because less viable. These less resistant cortical areas are to be found in varying isolated positions, but mainly where the cortex is thin, and they pertain especially in the tegmen tympani, tegmen antri, the posterior portion of the tegmen mastoideum, the posterior portion of the mastoid wall, in the region of the sinus, where the mastoid cavity is extended backward by frequent intercommunicating subcortical cells, and at the mastoid tip.

The diseased mastoid cavity being largely filled with highly vascular redundant granulomata capable of exerting a considerable pressure, the sequence of a spontaneous perforation of the cortex, as is exhibited in operation where the first opening in the outer mastoid wall is followed by a forcible extrusion of pus, is the rapid expansion of the granulomata, so soon as circumvirent resistance is removed, with ejection of pus through the opening into the surrounding area, whether downward into the tissues of the neck, the familiar cervical abscess of mastoid origin, or backward and upward into the cranial cavity with formation of the extradural abscess, so called, in reality an abscess like that of the neck, of mechanical causation, not an abscess, *per se*, of infective origin.

The limitation of these pus collections emanating from the mastoid is determined largely by the mechanical resistance of the surrounding tissues, by the influence of gravitation, and by the controlling effects of a secondary inflammatory process, such as is seen, especially in cases of perforation of the tegmen tympani and tegmen antri, where a limited meningeal inflammation has resulted in the building of a lymph wall about the invaded area.

A normal and constantly persistent mechanical agent for protection of the cranial cavity from invasion from the subjacent mastoid cavity is the outward brain pressure, downward upon the superior and outward upon the posterior inner mastoid wall, incident to the blood supply to the brain in these directions, a pressure sufficient to stop hemorrhage from a meningeal vessel or even from the sinus, at time of operation, if only the opening in the cortical wall be made large enough to permit the crowding of the bleeding vessel against the edges of the bone opening, by the normal brain pressure exerted from within outward.

Where the extradural abscess, of mechanical causation, has persisted a sufficient length of time, a secondary inflammatory process results, and the exposed dura will be found covered with granulomata, which also serve a part in the formation of the protective wall, limiting lateral extension of the fluid contents. In such instances the dura should be freed from granulomata by careful curetting, care being taken not to penetrate laterally beyond the limit at which the adherence of the dura marks the boundary of the abscess cavity; after curetting, the whole extradural abscess cavity should be thoroughly dry-scrubbed, and good mechanical drainage having been secured to it by a large cortical opening into the mastoid, it may be left to participate in the subsequent dressing of that cavity.

LATERAL SINUS THROMBOSIS

One of the complications to be looked for, especially in cases of prolonged suppurative disease of the mastoid, is the implication of the lateral sinus, either by inflam-

matory thickening of its wall adjacent to the mastoid,
and corresponding decrease of the lumen of the vein, or
by formation of a protective thrombus which may or may
not have become septic, according to its power of resist-
ance or the degree of invasion of septic material from the
mastoid cavity.

The possibility of such a complication, of a suppura-
tive process confined originally within a distinct cavity,
bounded by a more or less conservative firm bony wall,
emphasizes the importance of early operation when once
the suppurative character of the inflammatory process in
the mastoid has been definitely determined, and also the
importance at the time of operation, in all doubtful cases,
of uncovering the sinus by removing the contiguous mas-
toid cortical wall to a sufficient extent to permit free visual
and tactile examination of the vein. That this step should
be advisedly deferred until the remainder of the mastoid
or tympanomastoid cavity has been completely exente-
rated, is evidenced both in cases in which the hemorrhage
from an intact sinus, uncontrollable by more extensive re-
moval of the mastoid cortex, has necessitated plugging,
and in those in which the presence of a thrombus has
necessitated more extended manipulation and, possibly,
the precautionary measure of ligation of the jugular.

When well exposed the sinus wall should be carefully
examined, under good illumination, with a view to the de-
termination of any general thickening or of the less easily
perceivable limited areas of necrotic tissue. Normally,
the vein should show a dark blue color, should be easily
compressible by the finger, and a bent probe, with the
convexity of the curve pressed across the vessel, should
exhibit a flattened surface of the vein below and a con-

vex surface above it. In the event of inflammatory thick-
ening of the vessel wall in the area exposed, the deep
blue color is lost, or but faintly indicated, and tactile ex-
amination is insufficient to decide accurately between the
resistance offered by a thickened vessel' wall or by an
occluding thrombus, in which case the question must be
answered by opening the sinus itself. This is best done
by means of a narrow-bladed knife or a pair of small
straight scissors, and either of these instruments is to
be much preferred to the hypodermic needle; both are
more certain of sterilization, and both give immediate
evidence of the existing condition when the lumen of the
vessel is entered. The cut should be made lengthwise of
the vein, which may be lightly compressed laterally, by
means of straight forceps, in order to give it a more
rounded contour. The free flow of blood may give suffi-
cient evidence of the integrity of function of the vessel.
In event, however, of the presence of an occlusive throm-
bus the incision should be extended to within a short
distance of the limit of the bony opening, but preferably
kept within that area, and the contents of the sinus ex-
amined by means of a small, blunt, unfenestrated spoon
or curette. If the thrombus is found to be septically
intact and firm below the opening made in the vein, it may
be curetted above until free bleeding has established an
effective lavage, the lower portion of the thrombus re-
maining untouched, and the wound dressed by the usual
method of packing, the small gauze sponges already men-
tioned being useful for this purpose.

That ligation of the jugular is not essential in all
cases of sinus thrombosis is evidenced by the large num-
ber of instances in which satisfactory recovery has oc-

curred without it; but these must be offset by the cases
in which recovery has been attained only through the
success of an intermediate battle with septicæmia and
those which have never recovered. The operation of liga-
tion of the jugular alone, or when coupled with resection
of the thrombosed vessel above the point of inferior liga-
tion, is simple and secure, and there are as yet wanting
evidences of any prejudicial effects.[1]   In the event of a
mural thrombus there is always danger of its mechanical
disintegration; with complete thrombic closure of the
vein, any possible deleterious effects upon the cerebral
circulation which might ensue from ligation of the inter-
nal jugular are already accomplished, and this operation,
subsidiary to the sinus thrombosis complication of mas-
toid disease, is in all such cases warrantable for the pur-
pose of safeguarding the general circulation.

LIGATION OF THE INTERNAL JUGULAR VEIN

To place a barrier before a growing septic thrombus,
to cut off from absorption into the general circulation
toxines, bacteria, and infective particles of a decomposing
sinus thrombus, and to prevent dislodged portions of such
a clot from being carried into the heart by the blood
stream when a thrombus is being removed from the sinus
above, it is advisable to ligate the internal jugular vein
as soon as the diagnosis of lateral sinus thrombosis has
been certainly established. The diagnosis is seldom posi-
tively made until, in the course of a mastoid operation,
the sinus wall has been exposed and inspected. After
such an examination, and upon arriving at the conclusion

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[1] K. Grunert. "Zur Gefahr der Bulbus Operation ; Bildung einer Ence-
phalocele." *Archiv für Ohrenheilk.*, v. 64, 1905.

that the sinus is thrombosed, the mastoid operation should be completed and a light aseptic dressing placed in the wound until the jugular has been ligated, deferring for the time being the opening of the sinus and removal of the thrombus.

The entire side of the neck, from the chin in front to the posterior border of the mastoid process behind, down to the clavicle, should be aseptically prepared by scrubbing with soap and brush and washing with alcohol. The line of incision is parallel with and along the anterior border of the sterno-cleido-mastoid muscle, beginning at a point opposite the angle of the jaw and extending downward and toward the median line four centimeters or more. In some cases it may be necessary to extend the incision from the tip of the mastoid process to the inner end of the clavicle. If a block or stiff pillow be placed under the patient's neck, so that the head hangs below the level of the shoulders, the sterno-cleido-mastoid muscle will be put upon the stretch, and its anterior border will thus be better defined as a guide. By cutting through the skin, subcutaneous tissue, and the platysma, layer by layer, checking bleeding by the application of hemostats as the operation proceeds, the deeper dissection being made with a blunt dissector or the scalpel handle, a comparatively dry dissection can be made. The wound should now be held open by retractors, the posterior retractor blade being so introduced as to enfold the belly of the muscle as it is freed from its sheath by progressive dissection. Picking up with blunt forceps the fascial sheaths that cover the muscle and separate the vessels, and cutting through such tissue guardedly with knife or scissors, the internal jugular vein and the carotid artery come

into view. Their relative positions and the pulsation of the artery serve to distinguish one from the other under ordinary circumstances, but it sometimes happens that in a state of phlebitis the vein presents an abnormal appearance. It is frequently much dilated and exhibits an apparent pulsation, which is afforded by the adjacent artery, or sometimes by an impulse transmitted from the larger vessels below. In such an event the vein can be distinguished by raising it from its bed, in which condition such pulsation ceases.

Having exposed the vein and slit its sheath longitudinally for a distance of two centimeters or more, two catgut ligatures should be placed around the vein with the aid of an aneurism needle or other ligature carrier. (Plate M.) The lower ligature should be pressed downward as far as possible and tied. The second one is then carried upward for the distance of one centimeter and tied, and the portion of vein intervening between the ligatures is raised and completely divided. In cases where inflammation of the vein is evident below the jugular bulb it is wise to continue the operation by resecting the upper section of the vein as completely as possible, even up to its bulbous portion. To do so, the slit in the sheath surrounding the vein should be carefully extended upward, and all branches entering the vein should be ligated in the order they are encountered, the chief branch being the facial vein which enters the internal jugular in its middle third at an angle of about forty-five degrees.

While exposure of the internal jugular at the anterior border of the sterno-cleido-mastoid muscle is the usual method of procedure, and perhaps the simplest way, this
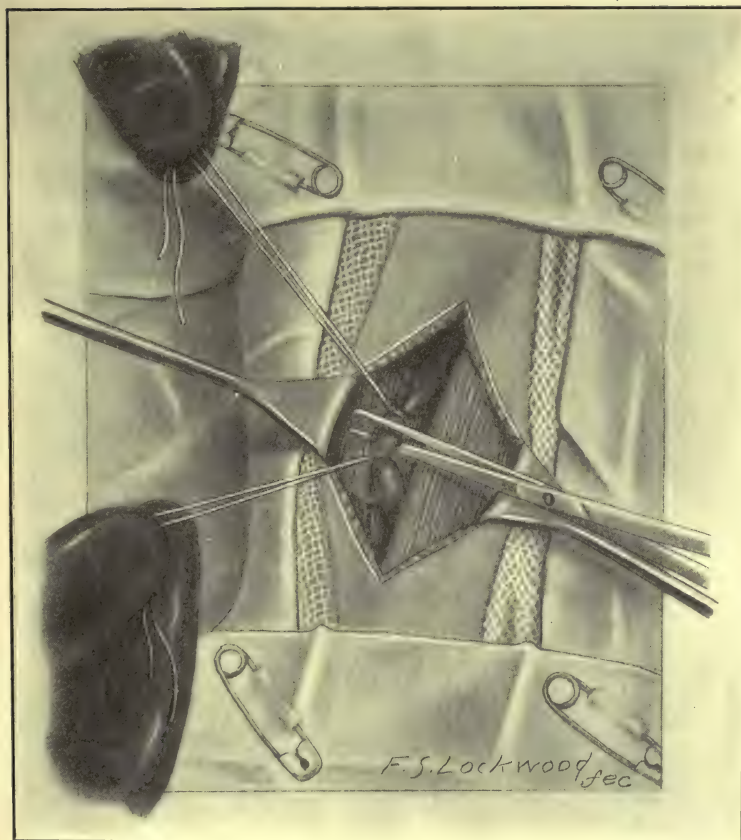
PLATE M.—Ligation of Left Internal Jugular Vein $2\frac{1}{2}$ cm. Above the Clavicle.

vessel may be reached by cutting directly through the belly of that muscle, in its middle third, the fibers of which separate easily and close again compactly over the vein when the operation is completed. The exact location of the vein during such dissection can always be determined by feeling the arterial pulsation of the carotid with the examining finger.

Unless the operation has established direct connection with a septic tract above, the neck wound should be closed for healing by primary intention, using the subcutaneous or interrupted suture and applying an aseptic gauze dressing. At this point the surgeon may again turn his attention to the thrombosed sinus, which can now be freely opened and its contents removed by curettage and irrigation of the lower portion, the reëstablishment of the blood current above serving to wash that section after removal of the clot.

INTRADURAL AND BRAIN ABSCESSES

That the persistence of a suppurative process in the epitympanum and mastoid may result in the causation of intradural abscesses and the formation of abscess cavities in the brain tissue itself, is evidenced by the increasing enumeration of cases of so-called otitic brain abscess and by the formulation of rules for their detection and relief. The more common seats of intradural abscesses are, as would be expected, the areas in which the extradural accumulations of pus are usually found, while the intracerebral abscess proper of otitic origin, the result of a translated septic infection, may be found in any portion of the brain, but more commonly in the lateral basal and posterior portions of the cerebrum, and in the cerebellum,

and may exist, in default of invasion of the more pro-
nounced sensory and motor tracts, for a considerable
period of time (months, or even years) without other than
systemic evidence of its presence. Under these conditions
their preoperative localization has difficulties which do not
pertain where peripheral symptoms point to the situation
of the centrally located cause, and make the course of
surgical intervention plainly indicable.

The primary point of intracranial infection of otitic
origin being a perforation of the cortical substance of
some portion of the tympanic or mastoid wall, with ex-
posure of the dura, a fibrous resistant membrane, care
should be taken not to penetrate it and expose the more
vulnerable tissues which it incloses, unless there are indi-
cating symptoms of a deeper area of infection already
established, in which case the dura should be freely ex-
posed over as large an area as the configuration of the
tympanic or mastoid wall will permit, and the dura slit
by means of a narrow-bladed bistoury, and this opening
enlarged by means of lateral scissor cuts. In the event
of a proximate necrotic brain area with septic products
encapsulated within the brain tissue, a rapid extrusion of
brain substance through the dural opening will indicate
its presence, and possibly the direction in which it is to
be sought; in default of this, careful exploration of the
brain substance, guided either by previously observed
peripheral localizing symptoms or by the statistically de-
termined probable location of the abscess, should be made
either with a large trocar or, preferably, a hollow straight
director or some expanding instrument, a slender-bladed
hemostat, for instance, experience with a trocar having
shown it to be ineffective in the event of thick pus min-

gled with detritus, or from a clogging of its lumen in passing through the encapsulating abscess wall.

The general course to be followed in a case of suspected brain abscess of otitic origin should be, first, the observance of all possible peripheral localizing symptoms, and, second, as complete an operative exposure as possible of the tympanic and mastoid cortical walls, with a view to following surgically the course of the septic infection from the point of its otitic origin inward. For this purpose the tympanomastoid exenteration is the most effective preliminary operation, and the location of intradural abscess of otitic origin by direct infection through the dura, as contradistinguished from the brain abscesses of indirect infection through the medium of the circulation, as in septic thrombus of the sinus for instance, is, in the cerebrum, directly over the tegmen tympani and tegmen antri, and in the cerebellum, above and behind the tegmen mastoideum and posteriorly to the mastoid sinus wall, the extent of the abscess cavity being mechanically limited by normal resistant brain structures and by its own inclosing wall of inflammatory origin.

While usually single, the brain abscess of direct intradural infection is occasionally multilocular, the evacuation of an abscess, with persistence of the locally evidenced intracerebral pressure symptoms, being followed by spontaneous rupture of the inclosing wall of a second abscess cavity, or, surgical penetration of the wall, which offers a distinct sensation of resistance to the touch, liberates and permits another flow of pus. The abscess contents vary considerably macroscopically from a thin fluid mixed with brain detritus, in more acute cases, to a thick, greenish, malodorous fluid in cases of longer persistent abscess, the

length of time during which an intradural abscess may exist without causing other than mild septic symptoms being dependent upon its location and the general anti-toxic resistant capacity of the individual.

In any case of immediate, intradural, or remote brain abscess the opening made into its cavity should be large enough to provide for free mechanical drainage and to permit access for subsequent observation. The lymphoid encapsulation should be disturbed as little as possible co-incident with free clearance of its interior, and passage of its contents outward should be favored by the intro-duction of a soft - rubber fenestrated drainage tube or wicks of loosely rolled gauze. The immediate, intradural abscess being more accessible than the remote, may be treated much after the fashion of its often contiguous neighbor, the extradural abscess, and dealt with as a pro-longation of the mastoid or epitympanic cavity, this reser-vation, however, being always had in mind, that its ulti-mate wall is a limiting provision of tissue change, not a normal product, that it is readily invasionable, and that beyond it the healthy brain tissue, with its intimately anastomosing circulatory system, affords a ready medium for the translation of negative products.

In addition to provision for drainage, lavage of the abscess cavity with warm normal salt solution, under slight pressure, should be practiced at the daily dressing, unless contraindicated by the intervention of immediate pressure symptoms or the existence of symptoms of cere-bral irritation.

The ultimate issue in cases of immediate intradural abscess, in which neither meningitis nor encephalitis has ensued, has been fortunate in a sufficient number of cases

to demonstrate the process of repair in a gradual contraction of the abscess cavity, the supplanting of its lymphoid encapsulation by healthy granulomata, the reparation of the perforated dura by fibrous scar tissue, and the participation of the former abscess cavity in the granulomatous closure of the mastoid wound.

CHAPTER VIII

ADVENTITIOUS AURAL SURGERY

ADENOIDS

SINCE the organ of hearing is the channel through which, preëminently, in childhood the stimulus to mental development comes from the outer world, a fact of which we have ample evidence in the results both of physiological experiment and clinical experience, and since the enlargement of Lushcka's glands is a disease of childhood particularly, though its consequence may continue through adult life, a recognition of the relation which this disease bears to the hearing power is of great importance.

Pathology of Adenoids and Adenoid Deafness.—The pharyngeal tonsil, or tonsil of Luschka, is a collection of lymphoid tissue in the mucous membrane lining the vault of the pharynx, normally limited to a small area at the junction of the posterior pharyngeal wall with its roof, but occasionally so extensive as to cover the vault and entire space between the mouths of the tympanopharyngeal tubes. Microscopically, this so-called tonsilar tissue differs from the neighboring mucous membrane of the nose and pharynx only in its greater thickness and preponderance of lymphoid cells and glandular elements; it is a lymphadenoid tissue that has developed in embryonic

288

mucous membrane through the accumulation of lymphocytes in its fibrillated connective-tissue layer.

The normal tendency of this lymphoid tissue is to undergo atrophy as the age of puberty approaches, but, through the existence of a lymphatic diathesis or the occurrence of some provocative irritation, a proliferative lymphadenoid growth may be precipitated, and there results the formation of the so-called adenoid vegetations. On section these growths exhibit an irregular series of lymph nodes in an embryonic connective-tissue reticulum, the latter being quite vascular, while the lymphatic masses are poorly supplied with blood vessels.

The presence of adenoid growths in the nasopharynx affects the organ of hearing and its function mainly in two ways—by interference with the ventilation and with the blood supply of the middle ear. To clearly review the manner of this interference it is well to consider the means provided for continuing a definite supply of air in the middle ear and for maintaining a just balance of the arterial and venous circulation in that part of the organ of hearing which suffers most immediately from the filling of the nasopharyngeal cavity and consequent closure of the tympanopharyngeal tube. This passage, which is both drain and ventilating shaft, is in the child both shorter and wider than in the adult, its tympanic orifice is comparatively large, but the pharyngeal orifice is indicated only by a slight depression or fissure in the lateral pharyngeal wall, and the posterior prominent portion of the tube which forms a decided projection in the adult is either wanting or is hardly noticeable. The former of these anatomical conditions, as is evident, favors rapid recuperation after restoration of patency of the tube, and

the latter renders that passage much more easily occluded at its faucial end by the pressure of any substance filling the nasopharynx. The tympanopharyngeal tube is not a constantly open ventilating shaft for renewal of the air in the tympanum, and as the air in the middle ear is being absorbed constantly, with greater or less rapidity, according to the state of the circulation in the mucous membrane, its renewal must be provided for by gaseous interchange, or by the operation of such mechanism as shall, by opening the tube and at the same time causing increased atmospheric pressure in the nasopharynx, assure the ventilation beyond peradventure.

This process, in which the acts of deglutition and of phonation play an important part, is provided for through the operation of two muscles, the levator and tensor palati mollis, both of which are double-action muscles, being attached at the one end to the soft palate and at the other to the anterior and inferior walls of the tube. Each voluntary movement of the soft palate, therefore, is accompanied by the contraction of the palatal ends of these two muscles and by a corresponding movement at the tubal ends, the result being a withdrawal of the anterior from the posterior wall of the tube and, at the same time, a depression of the inferior wall or floor of that passage, giving it a greater inclination downward toward the pharynx. The same movement which opens the tube, by lifting the soft palate, tends to compress the air in the nasopharynx, and so favors still further the ventilation of the middle ear.

The same simultaneity of action, and the same effect in a lesser degree, is found in phonation. In the production of all the consonant sounds, with exception perhaps

of the sibilants, there is more or less back pressure, pneumatic pressure, in the pharynx and nasopharynx, while with all the back consonants, so called, there is in addition a very strong and decided muscular contraction of the soft palate. In addition to these more active provisions for this purpose, namely, swallowing, speaking, crying, and the numerous coördinate muscular movements of the throat, there are the passive movements of the soft palate and the changes of air pressure in the middle ear which occur during sleep with each respiration.

With the presence of a growth in the nasopharynx this admirably working mechanism is interfered with, and, even if the growth is not sufficiently large to occlude the faucial orifices of the tubes, it interferes with the palatal movements and with the proper balance of air pressure in the nasopharynx, and is inevitably productive of injury to the ear; the result of the decreased air pressure being the production of a partial vacuum in the middle ear, with its consequent train of congestion, swelling of the mucous membrane, and trophic changes, of greater or less permanency, according to the duration of the abnormal condition. That it is not necessary that the growth should be a large one to influence the ear is shown by the effect which a small growth has upon the pronunciation of all the nasal consonants; that is to say, upon the palatal movement. Where the growth is large and exerts considerable pressure on the walls of the nasopharynx, there is, in addition to the consequences already mentioned, an effect directly upon the blood supply of the tube and middle ear by interference with the return of the blood from the tympanum through the tubal into the lateral pharyngeal veins. A portion of the blood supply to the anterior

20

and superior portions of the tympanic cavity and to the membrana tympani comes through a small artery running along the upper wall of the tympanopharyngeal tube, the blood so supplied being returned in part through veins running superficially downward in the tubal mucous membrane. Mechanical pressure on the lateral pharyngeal wall in the neighborhood of the tubal orifice may therefore result in a blood stasis in the middle ear and the consequent clinical phenomena of congestion of the mucous membrane, progressive rarefaction of the air in the tympanic cavity, and retraction of the membrana tympani.

Diagnosis (Local and General Symptoms). — The symptoms indicating the presence of adenoids vary in degree according to the length of time the air tract has been obstructed, for the immediate and remote effects of adenoid vegetations depend chiefly upon the mechanical obstacle which they offer to the passage of air through the natural respiratory channels. Imperfect nasal respiration in the child means imperfect health and imperfect development, with the danger of permanent structural changes being induced in the middle ear and in other parts of the body. The first symptom to attract attention is that of difficult breathing, especially at night. This may be noticeable in very early infancy, even shortly after birth in some instances, and where an abnormal amount of lymphoid tissue is present congenitally the child usually nurses with great difficulty. Older children develop the forced habit of mouth breathing, and this is accompanied by the more or less constant condition of nasopharyngitis or by repeated attacks of "cold in the head." The facial expression of a child with adenoids

is characteristic. The mouth hangs partly open, there is a dull, heavy look about the eyes, an air of inattention to or lack of interest in its surroundings, and a general appearance of stupidity. Taken with the history of snoring, this appearance generally means obstructed respiration, and, in children, obstructed respiration not associated with acute inflammatory disease, almost invariably means a postnasal growth; hypertrophied turbinates or other growths in the nares proper being uncommon in childhood.

Inspection of the cavity of the mouth will usually reveal a high palatine arch, so marked in many cases as to be a deformity. The soft palate looks thick, and often seems to be bulged forward and immovable. Enlarged follicles are often seen on the posterior pharyngeal wall and the faucial tonsils are very apt to be simultaneously hypertrophied. Where the condition has been one of long standing there may be remote evidences of impaired nutrition—that is, the youth is frail and ill-nourished in appearance, perhaps below the average in height or weight, and the chest is thin and flat, with deep depressions of the intercostal spaces, making the ribs appear unusually prominent. With this arrested development there may be a variety of symptoms arising from an insufficient supply of air, such as headache, lassitude, inability to study or to do anything requiring mental concentration, and occasionally more severe reflex disturbances, such as nausea, vomiting, and melancholia.

The train of aural symptoms which come from the presence of adenoids is such as would result from interference with the normal ventilation and nutrition of the middle-ear tract, and are more or less permanent, accord-

ing to the duration and size of the adenoid growths. In the earlier stages, when the growth is small, the ear is noticeably affected only when, in addition to the bulk of the growth in the nasopharynx, there is added the encroachment upon the space of that cavity by swelling of the mucous membrane, accompanying so-called head colds. As the growth increases, less and less swelling effects the deleterious purpose, and the intervals of freedom from impaired hearing, nocturnal earache, and subjective noises in the ears become shorter and more rare. In the meantime changes are taking place in the structures of the middle ear which are more or less permanent; the preponderating atmospheric pressure on the outer surface of the membrana tympani pressing that membrane inward and allowing the relaxed tendon of the musculus tensor tympani to contract and hold the malleus, and with it the membrana tympani, in its abnormal position tends, as does also the thickening of the mucous membrane, to permanently impair the mobility of the sound-transmitting mechanism of the middle ear, or, impairment of nutrition, lowering the vitality of the delicate tissues in the middle ear, favors the setting up of an ulcerative and suppurative process under the necessary additional provocation.

In reference to the aural symptoms, then, the cases may be divided into three classes. The first includes those in the earlier stages of the adenoid growths, which have had occasional earache and the occasional impairment of hearing apparently readily referable only to what is called a head cold. These children have very variable hearing, are frequently accused of inattention and disobedience, and are either too young to know or have too slightly noticeable an impairment of hearing to

appreciate that their derelictions are sins of the flesh and not of the spirit. In the second class are the more advanced cases, in which, the preliminary stages being passed, the impairment of hearing and the structural changes have become recognized as fixed facts, the impairment of hearing in some of these cases being so great and so persistent that the child is regarded either as a deaf-mute or even as idiotic, the well-known effect of obstruction of the hearing upon the mental development favoring the latter supposition. To the third class belong those cases in which suppurative otitis media is a result of the disease in the nasopharynx plus some local exciting cause, or is merely a coincident.

To be certain of the presence of adenoid vegetations in the pharynx the posterior rhinoscopic mirror may be used and the pharyngeal vault inspected under illumination, or the examiner may gently pass his forefinger upward behind the soft palate and explore that space by the sense of touch. The growths will be felt as soft velvety masses, which bleed readily; the difference to tactile sense between a smooth wall of the normal pharynx and one blocked with vegetation being so marked as to leave little chance for error. With regard to the amount of this overgrowth of glandular tissue that may be contained in the nasopharyngeal cavity, it can only be said that it varies greatly; sometimes where but few symptoms have been present enormous masses can be seen and removed, while, on the other hand, in not a few instances a very small amount of such lymphoid tissue will cause the most pronounced symptoms.

Prognosis.—Not to appreciate the importance of promptly removing adenoid growths, or to neglect their

proper treatment, is to invite possible complications and troubles for the future.

The part that this lymphoid ring plays as a portal of entry for general infections has not always been fully appreciated. It has been demonstrated that the vast majority of retropharyngeal abscesses occur as the result of bacterial invasion through this tissue, and it is highly probable that the tubercle bacillus and the productive agent of the exanthemata frequently gain admission in this way. It is fairly presumable that the function of the pharyngeal lymphoid ring is similar to that of the faucial tonsil and that it possesses phagocytic properties differing only in degree therefrom. Lacking the capacity to destroy large numbers of bacteria that may be deposited upon its surface from the inspired air, it is more readily susceptible to their influence, and because of its close communication with the general lymphatic system, any infection of this tissue may be quickly followed by general systemic disturbance. The bacterial resistance power of the pharyngeal tonsil is still further diminished by the mild, chronic inflammatory process which accompanies its enlargement, by the effects of cold and of dampness, and by the influence of lowered vitality; conditions under which any hypertrophied lymphoid tissue offers a favorable nidus for infective organisms.

It is a useless expenditure of time and of nervous energy on the part of the patient to attempt to reduce these growths by local applications. Prompt and complete extirpation is the only reasonable form of treatment. Without operative help the child is reasonably sure to suffer with chronic nasopharyngitis and middle-ear dis-

ease, if not to become the victim of abnormal development, mental as well as physical, whereas an operation restores a permeable air tract at the least, and in the majority of cases produces gratifying results in improvement of hearing, in change of facial expression, and in rapid advance of the child toward a normal development. In the group of cases showing an associated suppurative otitis it will very frequently be found that the latter affection will resist treatment until the adenoid vegetations have been removed and the patency of the tympanopharyngeal tube has been reëstablished.

The dangers attending adenoidectomy, *per se,* are a negligible quantity. Much has been said concerning the advisability of operating with or without an anæsthetic, and stress has been laid by some writers upon the increased risk to life attending the administration of general anæsthesia in this operation. There is no gainsaying the fact that when operating under anæsthesia the risks of the particular anæsthetic used are added to those of the operation itself, but when we consider the mental and physical torture inflicted upon an average child by such an operation without general anæsthesia, the mental shock being sometimes of lasting effect, it seems only humane to recommend that the operation should be done under general anæsthesia as a rule, and only in exceptional instances under local anæsthesia or without any anæsthetic. The completeness of an operation deliberately performed upon a quiet patient, as compared with the more or less incomplete and unsatisfactory operation that must be done hurriedly upon a struggling child, is another strong argument in favor of operating upon these cases under anæsthesia.

Treatment (Adenoidectomy).—The selection of an anæsthetic is a matter of personal choice, or, perhaps better, a matter of familiarity with its administration. It is a generally accepted view that chloroform should be used cautiously, if at all, in persons having a lymphatic disposition. Ether serves the purpose fully, except that it is unpleasant to take and requires far more time for anæsthesia than is taken up in the operation proper. The present tendency among operators of large experience is to employ one of the more transient anæsthetics, such as nitrous oxide gas or ethyl chloride or bromide. Either of these will produce anæsthesia within two minutes, and insure a sleep of sufficient duration to permit the performance of the average thorough operation, the anæsthesia being supplemented by and continued under ether if more time is required.

In the light of twenty years of extensive discussion regarding the best method of operating for the removal of these growths, it is well to recall the admonition of Sir William Dalby, expressed in 1886: " If one thing more than another stands out in relation to what is written, said, and done in connection with this matter, it is the necessity of tolerance for other methods while advocating our own, and for the following reason: that it is characteristic of the complaint that if the growths are removed in any way, so long as they are completely removed, the patients get well."

No attempt, therefore, will be made to enumerate the various methods of operating. It seems quite sufficient to describe that operation which appears to have become most accredited and which in the hands of a number of men of exceptionally large experience has given perfect

satisfaction. Perhaps the operation may be described in two words as complete curettage. It has long been recognized that the attempted removal of adenoids by the Löwenburg or Hooper forceps, or any similar instrument alone, is apt to be incomplete and to be followed by recurrence of the growth. If curettement be performed with the Gottstein, or some adequate modification of that curette, and the details of its performance be carefully attended to, successful reduction of the mass is almost certain and recurrence is exceedingly rare. One application of the curette is generally quite sufficient to remove the entire adenoid, whereas with the forceps alone, because of the impossibility of grasping the whole mass at once, frequent bites must be taken off, and there are chances of leaving portions to serve as a basis for reproduction. With a very large growth, one reaching anteriorly beyond the mouths of the tympanopharyngeal tubes, a special curettement of the lateral walls or secondary use of the forceps immediately after the central curetting may be required, but if the proper curette for the case in hand has been selected originally this will rarely be necessary.

In the choice of a curette the contour of the cavity to be scraped should be borne in mind; it is desirable to remove all projections from the normal level of the roof and the posterior and lateral walls of the pharynx as far forward as the posterior cartilaginous borders of the tympanopharyngeal tubes, and for this purpose an instrument should be chosen the blade of which is approximately as long as the pharynx is wide, and whose cutting edge is directed away from the operator and slightly upward when the instrument is held horizon-

tally. The proper curve of the shaft and blade is shown in Fig. 31.

The exact position of the patient during operation is
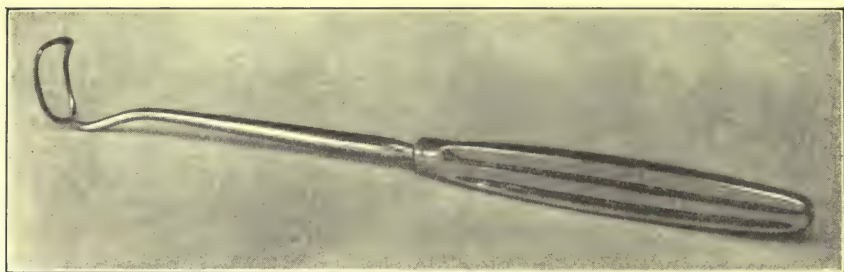
Fig. 31.—Adenoid curette.

not a matter of grave importance, although different operators enthusiastically advocate one method or another. Some prefer to have the child held erect, sitting in the lap of an assistant, others place the child on its side upon the operating table, with the head near the table edge or even hanging over the edge, while still others find that they can operate quite as satisfactorily with the child lying upon its back upon the table. The gist of the matter is, that if the following points be attained, the method may be a matter of indifference; that is, the head must be held firmly and controllably in an immovable position, permitting clear illumination of the throat, and it must be possible to rapidly throw the head forward, or to turn the head and elevate the body, as soon as the cutting is accomplished, in order to favor the flow of blood from the nose and mouth and prevent it from running into the larynx or esophagus. With the aid of a properly instructed assistant this can be quite as well done with the child in a recumbent position as when the patient is held in the erect posture or with the head drooping below the body.

Operation.—When the patient is fully anæsthetized, the assistant grasps the head firmly with one hand on either side and holds it immovable, with the chin slightly elevated. The operator inserts the mouth gag, depresses the tongue and, passing the curette carefully behind the uvula and soft palate, first draws it forward until it impinges upon the posterior border of the vomer, then, pushing strongly upward and backward, so as to keep the blade at all times pressed firmly against the pharyngeal wall, sweeps the instrument through the arc of a quadrant whose radius is an imaginary line from the
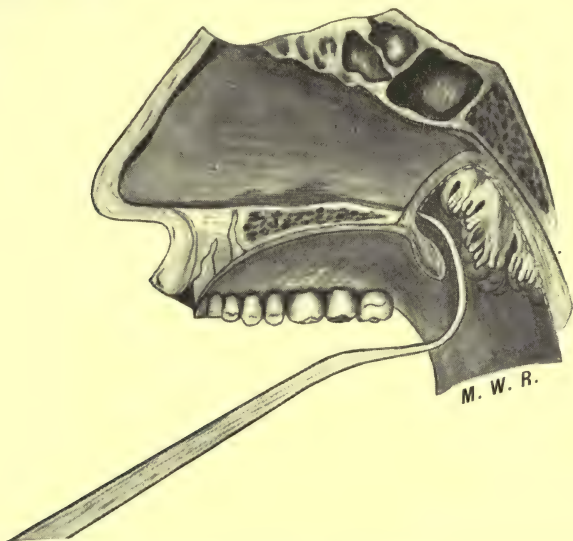
Fig. 32.—Illustrating the proper method of performing adenoidectomy with the curette, dotted line showing the course the blade should traverse.

junction of the pharyngeal roof and posterior wall to the tip of the uvula. The all-important feature of the operation with the curette solely is that if the instrument is thrust upward and backward immediately after it has passed the uvula, it is quite possible to leave a consider-

able mass of lymphoid tissue in the anterior part of the vault, or if the handle is drawn outward until the vomer is felt and then is forced backward without the upward pressure, it is almost sure to cut through a portion of the mass and leave a layer of vegetations attached to the roof. The success of the operation depends upon complete removal of all the projecting lymphoid tissue, and this can only be brought within the range of the knife by introducing the blade gently behind the soft palate, hugging the posterior edge of the nasal septum and the vomer, and then forcibly adhering to the walls of the cavity as the blade sweeps the vault. (Fig. 32.) Once the beginner has learned the importance of this rule he has made the complete adenoid operation a very simple procedure, and only rarely will he have occasion to follow the curette with an application of the forceps or of the smaller curettes adapted to the side walls. If the forceps are to be used as preliminary to curettage, the uvula and edge of the soft palate should be drawn forward by means of a blunt hook or flattened palate retractor, the forceps passed upward, opened, pressed upward to the pharyngeal vault, then closed and withdrawn with a slight twisting motion.

Immediately upon withdrawal of the knife the patient should be quickly turned upon the side, with the head over the table edge and the body elevated so as to favor the exit of blood from the mouth and nose; or, if the patient has been held in the erect position, the holding assistant simply bends forward with the child. Hemorrhage is usually quite free for the moment, but under ordinary circumstances soon ceases, and the child may be placed back upon the table or upon a couch. A nurse or

assistant should watch the patient carefully for a few minutes, however, to prevent any accumulation of blood in the mouth or nares and to promptly turn the child over should nausea supervene. In the event of protracted hemorrhage, gauze sponges, held in volsellum forceps, should be used to cleanse the cavity and to make pressure against bleeding points. There are no large blood vessels in the nasopharyngeal cavity to be wounded, and it is characteristic of the bleeding from these growths that it ceases completely in a few moments. The blood does not come with a gush, but trickles slowly downward over the posterior pharyngeal wall or makes its exit through the nose when the head is bent forward in the sitting position, and that which is not sponged out or which accumulates because the patient has not been turned or bent forward quickly enough after the cutting flows into the stomach, to be vomited later.

SUBCUTANEOUS AND INTRAVENOUS INFUSIONS

GENERAL CONSIDERATIONS.—The subcutaneous injection of normal saline solution for various purposes is a well-recognized therapeutic measure, and numerous reports of experimental and clinical observations made in the last few years seem to indicate that direct intravenous medication may become, in the near future, a useful auxiliary in the fight against sepsis. The otologist seldom encounters a severe hemorrhage and rarely has occasion to consider the replacement of large amounts of body fluids by infusion, but, while some of the most brilliant results accredited to saline injection have been noted in cases of surgical shock accompanied by great loss of blood, it has nevertheless a large field of usefulness even in spe-

cial surgery. As a cardiac and vasomotor stimulant in cases of postoperative shock without hemorrhage it is of great value. In cases of cardiac depression, before or during operation, attending severe local or systemic infections it may prove a worthy aid to the surgical treatment. Bloodgood has stated [1] that "in all grave surgical infections, especially with streptococcus, routine subcutaneous infusion three or four times in twenty-four hours is a very important aid in carrying the patient through the critical period." Finally, whenever a weak or debilitated patient has been kept under anæsthesia for a prolonged period of time, a subcutaneous infusion of saline solution will assist very materially to restore the normal tone. In addition to replacing the fluids lost by glandular secretion and hemorrhage under these conditions, it stimulates the kidneys to a proper activity and allays, in part at least, that distressing nausea and thirst which so often follows the taking of an anæsthetic.

Intravenous infusion is employed to-day almost solely as a means of combating septicæmia. It is a needlessly radical operation to secure the results above outlined as obtainable with the use of subcutaneous injections, and hence is to be reserved for the conditions that cannot be met by the simpler method. As yet no very satisfactory results have been obtained through the agency of antitoxic serums for the pyogenic diseases, and until such time as the laboratory may provide antitoxines for specific infections it is justifiable to attempt neutralization of toxines in the blood of a septicæmic patient by the intravascular use of chemical or physiologic antidotes.

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[1] *Progressive Medicine,* December, 1900, p. 114.

Although much work has been done experimentally and clinically in this line, it is not yet possible to determine accurately the indications for the employemnt of any of the various substances injected intravenously nor to define their action in producing the good results occasionally obtained.

The original suggestion of intravenous infusion for the cure of systemic infection was based upon the idea of washing away or diluting the toxic products in the blood. The introduction of a quantity of normal saline solution, particularly if a small amount of blood is first abstracted, has the effect of directly diluting the poison and of indirectly aiding in its removal through the stimulation of excretion by promotion of diuresis. Whether better results can be obtained by the intravenous use of saline solutions than by the subcutaneous injections is still an open question. Experimentation with various strengths of saline solution and of solutions containing other salts than sodium chloride, to more nearly approximate the chemical constituents of blood serum, seems to have demonstrated that the so-called normal saline solution (0.6-per-cent solution of sodium chloride in sterile water) is not the safest and best fluid for intravenous use. When used subcutaneously this solution is altered in its passage through the lymphatics and tissues by an interchange of fluid and solid constituents with the natural salts and fluids of the body, so that by the time it reaches the blood vessels it is in chemical harmony with the serum. If it be introduced directly into the veins, however, a solution of the single salt of this strength exerts a destructive influence upon the red blood corpuscles. In the effort to overcome this defect many combinations of the sodium,

calcium, and potassium salts, in varying strengths, have been tried. A solution of sodium chloride of 0.9 per cent is more nearly isotonic with the normal blood, and to this a small percentage of the chlorides of calcium and potassium may be advantageously added, as suggested by Ringer. The physiological experiments of Dawson [1] have shown, however, that Ringer's formula contains too large a proportion of calcium chloride to make it safe for universal use, and that the following modification of that solution would seem to meet all the requirements:

Sodium chloride	0.90
Calcium chloride	0.01
Potassium chloride	0.01
Distilled water	99.08
	100.00

As this solution answers equally well for subcutaneous use it may well be kept as a stock physiologic salt solution as distinguished from the 0.6-per-cent solution of sodium chloride, which can still be employed for general use, such as irrigations and cleansing purposes.

Following close upon the idea of lavage came, very naturally, attempts to meet the bacteria or toxic substances with some bactericide or active antiseptic. Foremost among the agents reported as successfully employed in this way have been nucleic acid and the silver salts. The colloid preparation of silver, known as Collargol, has been enthusiastically recommended by Crede, who believed that its action was that of a bactericide. The value of nitrate of silver in intravenous infusion was demon-

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strated in a series of cases reported by Hume. Crede
advises the intravenous injection (by the " closed " method
or the insertion of the hypodermic needle through the
skin and directly into the lumen of the vein) of 4 to 6 c.c.
of a two-per-cent solution of the salt in sterile water.
Hume employs a freshly prepared ten-per-cent solution
of nitrate of silver and dilutes this by mixing 1 c.c. with
1,000 c.c. of sterile water (each 100 c.c. of finished solu-
tion containing 10 mgm. of silver). Of this solution he
injects from 300 c.c. to 500 c.c. as a dose. Issaeff and
Salierin suggest the use of a two-per-cent solution of
neutralized nucleic acid in normal salt solution and the
injection of 50 c.c. as an average dose.

Nearly all workers with these solutions, except Crede,
consider that the beneficial action is the result of changes
in the blood cells and not due to any bactericidal proper-
ties. They all agree that an increased leucocytosis is the
most prompt and constant effect of the infusion, and that
unless such a response is met with no improvement is
likely to follow this or repeated injections. The imme-
diate effect of the infusion of silver is frequently a dimi-
nution in the number of leucocytes, but within a few hours
a marked change takes place and a pronounced hyperleu-
cocytosis result. Hume [1] advances the theory that in this
primary destruction of the blood cells, for the red cells
participate in the decline in number per cubic centimeter,
some antibodies are set free, which increase the bacteri-
cidal power of the blood, and that in the great increase
of leucocytes which follows a new army of fresh cells is
provided to do battle with the remaining foe. The pro-

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[1] *New Orleans Med. and Surg. Jour.*, October 1904, p. 337.

21

tective value of a leucocytosis in pyogenic infections will be acknowledged without question, and the hypothesis regarding the powers of the hemolytic bodies is worthy of further consideration.

Hahn demonstrated long ago that during the stage of hyperleucocytosis the blood of men and animals possesses a higher bactericidal value than does normal blood, and Von Mickulicz raised the question whether artificial hyperleucocytosis might not be of value in practice as a prophylactic, setting forth his belief that by anticipated mobilization of large masses of leucocytes before the bacteria that had gained entrance could accumulate in large numbers, their deleterious influence could be more easily counteracted than if the reinforcement of the leucocytes were delayed until the microörganisms had gained a powerful hold. Up to the present time intravenous injection of these solutions have rarely been used until the septicæmic patient was beyond the help of any other known remedy, and consequently the percentage of lives saved by this means has been small. If it should be proven that it is a therapeutic measure having a logical, scientific basis, its earlier employment will be productive of more satisfactory results. In the meantime, in view of the experimental and clinical demonstrations referred to, and especially in view of the very grave prognosis attending such cases of sepsis as are met with in connection with lateral sinus thrombosis and the cerebral complications of suppurative otitis media, we are justified in resorting to infusions much earlier than has been the custom. Subcutaneous infusions may be given even before surgical intervention and continued later without danger; and, should the symptoms of sepsis persist after the operation and

the patient show no marked signs of improvement, an intravenous infusion of silver should be tried, without waiting for evidences that the patient is in extremis.

SUBCUTANEOUS METHOD.—A graduated irrigation bottle, several feet of soft-rubber tubing, and an ordinary aspirating needle constitute the instrumental outfit. Sterile normal saline solution seems to be satisfactory for injection under the skin, although the suggested modification of Ringer's solution is, scientifically speaking, more desirable. It should be heated to a temperature of 100° F. for use. The entire apparatus should be sterilized by boiling, and the solution transferred to the infusion bottle only when the operator is ready to employ it. In hospitals the solution and apparatus can be kept sterile in readiness for emergency, and no delay need be experienced save the time required to heat the fluid.

Aseptic preparation of the skin at the site of intended puncture is to be made as carefully as before any other surgical procedure. Some region where there is an abundance of loose connective tissue and good vascularity forms the choice location for such an injection, since it will accept a considerable quantity of fluid without painful pressure, and systemic absorption through the lymphatics will be most rapid. For these reasons the axilla, retromammary tissue, abdominal wall, outer surface of the thigh and lumbar region are most frequently chosen, and when it is necessary to give repeated injections such spots may be used alternately. The needle should be plunged through the skin into the subcutaneous areolar tissue over or between the muscles and the solution allowed to flow slowly by gravity, the reservoir being elevated twenty or more centimeters above the patient, until

from 300 c.c. to 500 c.c. have been introduced; when the breast is chosen as the place for injection, care should be exercised to insert the needle at the periphery, preferably on the axillary side, and deep enough to pass under and avoid glandular structures, and, if the axilla be selected, the needle should enter at the posterior edge of the pectoral muscle so as to direct the current toward the axillary pit.

INTRAVENOUS METHOD.—The apparatus described above may be used and the same method followed, except that the needle point is inserted into the lumen of a vein instead of into subcutaneous tissue, the so-called "dry method," but it is considered better surgery to expose the vessel, introduce a cannula, and transfuse directly. Chance for additional vascular infection is afforded by the passage of a needle through the possibly nonsterile deep layers of the skin before entering the vein. A small, slightly curved glass cannula, with a blunt smooth end, may be used. The margins of its opening should be perfectly smooth and the extremity slightly bulbous, to prevent slipping of the ligature.

Any superficial vein of sufficient size, preferably on the arm or leg, may be selected to receive the injection, and by applying a bandage tightly on the proximal side the vessel can be made to stand out more prominently. Having aseptically cleansed the skin over this area and secured local anæsthetization, an incision is made parallel with the course of the vein so as to expose it for a length of 2 to 3 cm. Two catgut ligatures are passed around the vein, one at either end of the exposed portion, and the distal one tied. A small cut is then made in the vein to admit the cannula, which should be introduced with the

transfusion solution flowing—to avoid the entrance of air —and the proximal ligature is tied only tightly enough to retain the tube in place and prevent escape of blood. Removing the tourniquet above reëstablishes the venous channel, and the infused fluid takes its course toward the heart. By varying the height of the reservoir above the patient the rate of flow can be regulated to suit the occasion; in general, the infusion should be made slowly. Upon withdrawal of the cannula the ligature which surrounded it should be tied tightly about the vein and the wound in the skin closed and dressed as for primary union.

LUMBAR PUNCTURE

Despite considerable experimental work with lumbar puncture for therapeutic purposes and the demonstration that various remedies may be injected into the subarachnoid space without danger, the procedure has not gained much favor as a means of administering drugs, but is employed almost solely as an aid in diagnosis. Its value in determining the existence of meningitis and the character of infection is established, and the importance of such positive assistance is appreciated when the difficulties that stand in the way of a differential diagnosis between meningitis and other diseases, especially in children, are recalled. Wentworth,[1] whose careful investigations on this subject are deserving of the highest praise, has shown that "normal spinal fluid is absolutely clear and free from all cellular elements and fibrin," and that "the slightest cloudiness present at the time when the fluid is withdrawn, and caused by the presence of cells in the fluid, and the formation of fibrin in the fluid after it has stood

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[1] *Trans. Amer. Pediatric Soc.*, 1896, vol. viii, p. 84.

for several hours, are pathognomonic of an inflammatory exudation in the meninges, and are never absent in cases of meningitis."

His method of operating is as follows:[1] "The operation and the subsequent examination of the fluid should be as carefully performed as any other bacteriological investigation, in order to obtain accurate results. The back of the patient and the operator's hands should be made sterile. The needle should be boiled for ten minutes. The patient should lie on the right side, with the knees drawn up, and with the uppermost shoulder so depressed as to present the spinal column to the operator. This position permits the operator to thrust the needle directly forward rather than from side to side. An antitoxin needle, 4 cm. in length, with a diameter of 1 mm., is well adapted for infants and young children. A longer needle is necessary for adults and children over ten years of age.

"Aspiration of the fluid is not necessary, but some operators prefer to attach a hypodermic syringe to the needle to afford a better grasp for the hand. In this case the syringe would have to be detached to allow the fluid to flow. The additional manipulation, and possibly the defective sterilization of the syringe, might impair the value of the subsequent bacteriological examination.

"The puncture is generally made between the third and the fourth lumbar vertebræ, sometimes between the second and third. The thumb of the left hand is pressed between the spinous processes, and the point of the needle is entered about 1 cm. to the right of the median line, and

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[1] Mallory and Wright's "Pathologic Technique," p. 372.

on a level with the thumb nail, and directed slightly up-
ward and inward toward the median line. Care must be
exercised to prevent the point of the needle from passing
to the left of the median line and striking the bone.

" At a depth of three or four centimeters in children
and seven or eight centimeters in adults the needle enters
the subarachnoid space, and the fluid flows usually by
drops. If the point of the needle meets with a bony ob-
struction, it is advisable to withdraw the needle somewhat
and to thrust again, directing the point of the needle
toward the median line, rather than to make lateral move-
ments, with the danger of breaking the needle or causing
a hemorrhage. The smallest quantity of blood obscures
the macroscopic appearance of the fluid by rendering it
cloudy. The fluid is allowed to drop into an absolutely
clean test tube which previously has been sterilized by
dry heat to 150° C. and stoppered with cotton. The fluid
should be allowed to drop into the tube without running
down the sides. From five to fifteen cubic centimeters
of fluid is a sufficient quantity for examination."

The desired amount of fluid having been obtained, it
should be immediately examined to determine cloudiness.
The test tube should be held toward the light, and, if
necessary, compared with a test tube filled with distilled
water, the presence of even a finely divided sediment being
thus made appreciable. A perfectly clear spinal fluid will
not produce a sediment after standing for days, while
even a faintly cloudy fluid will deposit some sediment in
a few hours. Cultures should be made upon blood serum
in cases in which the fluid is cloudy, and cover-glass
preparations should be made from the fluid and from
the sediment for immediate examination. If stained with

Löffler's methylene blue the nuclei of the white corpuscles and the bacteria will take up the coloring matter, and the presence or absence of pyogenic microörganisms can be quickly determined. In meningitis secondary to purulent otitis media the germs most commonly isolated from the spinal fluid are the pneumococcus, streptococcus, and staphylococcus aureus.

APPENDIX

APPENDIX

Note 1.—*The Value of Paracentesis of the Membrana Tympani in Acute Suppurative Inflammation of the Middle Ear.*

Buerkner (*Archiv für Ohrenheilkunde,* August, 1904) draws the following conclusions in favor of this procedure as contrasted with the occurrence of spontaneous opening, based upon his observations in 450 cases, in 300 of which he did paracentesis, the remaining 150 cases having come to him after the opening in the drumhead had been spontaneously established.

Of the paracentesis cases seventy-six per cent were children and only twenty-four per cent adults. The spontaneous perforations were more common in adults, 63.3 per cent of these cases being children and 36.6 adults, the reason for this difference in the percentages in the two classes of cases being probably not so much the difference in the anatomical and pathological conditions as to the fact that in children the cases are brought to the notice of the surgeon at an earlier stage of the disease.

In an analysis of 200 paracenteses and 150 spontaneous perforations: Of the former 172 healed within three days, there was recurrence of the inflammatory process in but 13, and mastoid complication in but 1 per cent; while in the latter class 135 healed within three days, there were

26 cases of recurrence, and 7.4 per cent of mastoid complications.

The average duration of the inflammatory process, when paracentesis was done on the first day, was 7.6 days; when done on the second day, 7.9 days; and when done later than the second day, 8.6 days. When perforation occurred spontaneously on the first day the average duration was 17 days; on the second day the average was 24.7 days; and twenty-six per cent of the spontaneous perforation cases became chronic.

In the paracentesis cases there was less subsequent disturbance of hearing than in the spontaneous cases, the proportion in the former being three per cent and in the latter twelve per cent. The same advantage was shown in favor of paracentesis in reference to the liability of recurrence of the disease, namely, but 8.5 per cent, as against 20.7 per cent in the spontaneous perforation cases.

NOTE 2.—*Statistics of House Patients Treated on the Aural Service at the Massachusetts Charitable Eye and Ear Infirmary for the six months ending August 15, 1904.*

The following compilation, which has been made with the view of showing the number and kind of cases of mastoiditis treated at the above institution in the service of six months, as stated above, emphasizes also several already established points in the treatment of mastoid disease.

There were admitted to the wards during this time, having tenderness of the mastoid, 269 patients, ranging in age from five months to seventy years. Of these, 152

came to operation, while 117 were aborted—or about forty-three per cent of the cases having symptoms of mastoid involvement escaped operation.

Of these 152 operations, 140 were simple mastoids and 12 were tympanomastoid exenterations.

Of the simple mastoid operations, 116 followed acute suppurative inflammation of the middle ear, while 18 followed chronic suppurations; 6 cases followed previous mastoid operation.

One hundred cases following acute suppurations were without complications; 16 cases were complicated, as follows:

Cerebral abscess	1	Cervical adenitis	4
Cerebellar abscess	1	Erysipelas	4
Sinus thrombosis	1	Diabetes	1
Meningitis	3	Marasmus	1

Twelve cases following chronic suppurations were uncomplicated; 6 cases were complicated, as follows:

Sinus thrombosis (with ligation of internal jugular)...	1
Syphilis (with facial paralysis).....................	1
Bronchopneumonia	1
Tuberculosis	1
Meningitis	1
Enteritis	1

Two cases were operated upon in which no mastoid disease was found. In both instances the patients were subjects of hysteria. In one case this was complicated by a beginning erysipelas, starting over the mastoid process and producing redness and œdema in that location, while at the same time there was simulation of facial paralysis. Under these circumstances, while the hysterical element

was recognized, the other symptoms demanded an explor-
atory operation. In the other case the presence of head-
ache, chills, and vomiting, together with local mastoid
symptoms, seemed to call for operation, which, however,
went no farther than a skin incision, the underlying bone
being found normal.

Nine of the radical operations were without compli-
cation; 3 were complicated, as follows:

Sinus thrombosis (with jugular ligation) followed by
    leptomeningitis 1
Cerebral abscess 1
Facial paralysis 1

In recording complications in the foregoing cases
reference has been made only to such complications as
materially affected the course of the mastoid disease, and
cases of diphtheria, scarlatina, whooping cough, measles,
etc., are not noted.

The value of early interference in the treatment of
mastoiditis is shown in the statistics of those cases fol-
lowing acute suppurations. Of these there were 233, 116
of which were operated upon, while 117 escaped operation.
In those cases requiring operation, the duration of the
inflammation prior to admission to the hospital averaged
21.87 days. In the cases which escaped operation, the
previous duration of the inflammation was 10.68 days.
In other words, the average acute case which has continued
but ten days before treatment is applied may be aborted,
while the average case which has lasted twice this time
will demand operation.

Regarding the comparative previous duration of mas-
toid tenderness in operated and unoperated cases, almost

exactly the same ratio obtained. The average duration in the operative cases was 11.76 days, while in the un-operated cases it was 5.57 days.

It goes without saying that many cases of much longer duration than these figures would indicate may be successfully combated, and, on the other hand, that it is not always possible to arrest the course of the disease, even when seen at the earliest possible moment. In one case, that of a nurse from a neighboring hospital, the acute inflammation had lasted but twenty-four hours and the mastoid tenderness but six hours when she was admitted to the house, and yet it became necessary to operate.

Another statistical confirmation of a well-recognized condition relates to the almost universal occurrence of œdema in the presence of mastoid inflammation, either over the mastoid itself (or just below or back of its tip) or as manifested by a drooping of the inner portion of the posterior superior wall of the membranous canal. Of the 116 operative cases just referred to, 110, or ninety-five per cent, presented either sagging of the canal wall, œdema over the mastoid process, or a postaural abscess. Sagging of the canal, with or without œdema of other parts of the mastoid, which may be taken as the most conclusive single diagnostic sign of mastoid implication, was present 76 times, or in sixty-six per cent of cases. Œdema of the mastoid process, either with or without sagging, was present in 48 cases; both sagging and œdema (or postaural abscess) in 50 cases. Sagging alone was found 28 times; œdema alone, 12 times. Postaural abscesses alone (for the most part of course in children, in whom drooping of the canal wall is sometimes difficult to detect) occurred 41 times.

On the other hand, that the absence of a sagging canal wall or of œdema may be taken as evidence that the mastoid cells have probably not been seriously invaded is shown by the records of the 117 acute suppurative ears with mastoid tenderness in which operation was avoided. Of these cases 104, or about ninety per cent, showed neither œdema nor bagginess of the canal wall, 2 cases had both bagging and œdema; 2 œdema alone; and 10 sagging alone.

The average length of time required for subsidence of mastoid symptoms in those cases unoperated upon was 5.57 days.

Note 3.—*Description of the Algesimeter.*

The algesimeter has been in use for so brief a time and employed upon such a small number of cases that it is impossible to make a very positive statement regarding its value as an aid in determining the degree of mastoid tenderness. From a limited experience with it at the Baltimore Eye, Ear, and Throat Charity Hospital it may be said that it gives promise of being a useful adjunct in determining the existence of mastoid tenderness, in mapping out the tender areas, in showing varying degrees of tenderness at different points, and, possibly, in becoming helpful in estimating the progress of mastoid inflammation and indicating the necessity for surgical treatment.

The instrument is a modification of the combined piezometer and algesimeter described by Dr. Howard A. Kelly in the *Johns Hopkins Hospital Bulletin*, September, 1904, page 293. It consists of a fenestrated cylinder in which a slender piston rod moves against a resistance

spring. The outer end of this rod is capped by a smooth, spherical button, and the inner end is attached to an indicator that slides in the fenestrum. The margin of the slit in the cylinder is marked to show the amount of pressure exerted upon the piston, being graduated in hundreds from zero to two kilograms. With such a device it is possible to determine accurately the amount of pressure required to elicit tenderness at any given spot. If pressure be made with this instrument over the antrum or mastoid tip of a normal person the full amount of power it registers, 2,000 gm., will be borne without material discomfort. In no case of mastoid inflammation with which it has been used, however, could such pressure be endured (usually not more than 700), and, as far as can be said at present, the more advanced the mastoid disease the less pressure required to bring forth a complaint of pain.

FIG. 33.—The algesimeter; an instrument for the estimation of mastoid tenderness.

A brief history of one interesting case will suffice to point out the possibilities of the instrument. A young

22

woman with acute suppurative middle-ear disease of both ears, following influenza, was admitted to the hospital with fever, pain in and about the ears, and otorrhœa. No swelling or redness in the mastoid region. On the right side a pressure of 100 gm. over the antrum elicited tenderness, 200 gm. produced pain, and 300 gm. severe pain; on the left side it required 200 gm. pressure to bring forth tenderness, 300 gm. real pain, and 600 gm. such pain as to compel cessation of pressure. A double mastoidectomy was performed, both antral cells were found to be filled with pus and granulation tissue, and the right side was the most acutely and extensively diseased.

NOTE 4.—*The Localizing Symptoms of Brain Abscess.* Written by DR. GEORGE ARTHUR WATERMAN, Boston.

Since brain abscess resulting from ear disease is generally found in the temporal lobe or in the cerebellum, the localizing signs of lesions in those regions are of value in many cases.

The right temporal lobe, of course, represents one of the silent areas of the brain, and small abscesses limited to this lobe give rise to only general symptoms. While this may be true to a certain extent of the left temporal lobe and the hemispheres of the cerebellum, there are, nevertheless, often present, with lesions in these, definite localizing signs.

The characteristic disturbance resulting from involvement of the left temporal lobe is a sensory aphasia, or inability to comprehend spoken language. The patient is able to express himself, oftentimes fairly well, but his inability to respond relevantly to one addressing him may

mislead the examiner to attribute this symptom to mental impairment, and so overlook a sign of the greatest value; and this mistake is more easily made on account of the general dullness which is liable to be present.

If the destruction of this center be not complete, this word deafness may not be absolute, and the patient may still be able to understand simple and frequently used words, while the longer words and more complex sentences confuse him.

Allied to this sensory aphasia and frequently associated with it is the symptom of word-substitution or paraphasia, where the patient miscalls objects and uses wrong words, especially nouns and pronouns. In presenting this symptom he often coins meaningless terms or may substitute words of another language.

If the word-deafness be marked, as in complete destruction of the center or its afferent fibers, the jargon used by the patient causes him no annoyance, since he is unable to detect the lack of sense in his sentences; but where the paraphasia is due to a simple interruption of the conduction fibers from the auditory centers to Broca's convolution, which pass through the island of Reil, the failure to recognize spoken language is not present, and much annoyance may be caused the sufferer by his futile attempts to make the phrases express his ideas. In a like manner the conduction fibers connecting the visual with the auditory centers may be involved, rendering the patient unable to read aloud properly; and these symptoms may be present in varying combinations.

Nicety of localization by the exact degree of sensory aphasia has not, up to the present time, however, been practical, except that a lesion of the first convolution of

the left temporal lobe (in a right-handed individual) gives rise to the complete form of word-deafness. This is true of a subcortical lesion destroying the afferent fibers as well as of a cortical lesion involving the center itself.

In addition to this it is recognized that lesions in this proximity cause incomplete forms of sensory aphasia, from pressure and involvement of fibers in varying modifications.

The extension of an abscess inward from either temporal lobe may involve the motor fibers of the internal capsule, giving rise to paresis of the leg, arm, and face successively in this order. This is an important sign in distinguishing the deep temporal abscess from the superficial form, which, in extending upward along the surface of the motor cortex, involves the projection system in the order of face, arm, and leg.

An abscess of considerable size in either temporal lobe may, by pressure or extension downward, cause a paralysis of the oculomotor nerve of the same side, and thus give rise to ptosis, dilated pupil, and inability to roll the eye inward, upward, or downward.

The optic tract, too, lies in close relation to the first temporal lobe, and pressure on this may cause a hemianopsia, the patient being unable to see objects on the side opposite the lesion.

Abscesses may develop in the extreme lateral portion of the cerebellar hemispheres without giving other than general symptoms of brain abscess, but as they approach the median line definite signs become manifest, characteristic of cerebellar disease.

In general, cerebellar abscesses are apt to give rise to early and intense signs of intracranial pressure, owing to

the development of internal hydrocephalus from obstruction to the outflow of ventricular fluid. For this reason optic neuritis may make its appearance early and develop rapidly, while the headache and vomiting become more marked than is the case when other parts of the brain are diseased.

The stupor resulting from pressure is a prominent symptom in such cases, and frequent yawning has been several times observed, although its exact significance is not clear.

The location of the headache is not, as a rule, a guide to the seat of the lesion, since it is quite as often frontal as occipital. The attacks of vertigo may, however, often be of value in locating the lesion, since in cerebellar disease they are often associated with apparent motion of surrounding objects, which seem to move from the side of the lesion toward the healthy side.

The staggering in cerebellar lesions is to be distinguished from the general unsteadiness due to increased intracranial pressure resulting from tumors elsewhere in the brain, for in the cerebellar cases there is apt to be a tendency to stagger always to one side. It is true that from the direction of the staggering it is not always easy to diagnosticate the hemisphere involved, since some patients stagger toward and others away from the side of the lesion, but this depends upon whether the abscess exerts an irritative or a paralytic influence on the mechanism of equilibrium.

Distinct from the staggering but related to it is the tendency for the patient to incline to the right or left from a straight line in walking, and this sign is generally better brought out by asking him to walk with closed eyes.

The clinical significance of the deviation to one side in walking is the same with that of staggering toward that side.

The fact that the head assumes definite positions in the case of lesions causing destruction of one cerebellar hemisphere has been well demonstrated by the experiments of Batten, and has since been repeatedly observed clinically.

This position results from a falling of the occiput toward the shoulder of the affected side, while the chin is tilted upward and away from that side—i. e., the side of the lesion. In some cases of cerebellar disease there is marked retraction of the head, and the fact that this may be associated with Kernig's sign may give rise to suspicion of meningitis, although the meninges are not necessarily involved.

Weakness of one side of the body in cerebellar cases may be due to either one of two causes. First, a deep abscess involving Deiter's nucleus causes paresis of the homolateral limbs, and if the lesion is an irritative one, the limbs of the same side may be spastic, while if it has a paralytic action the limbs are paretic and atonic.

This paresis is frequently associated with ataxia of the arm of the same side in varying degree. The eye muscles, too, may be affected by such a lesion in such a way that conjugate deviation results, in the irritative stage looking toward the side of the lesion, and in the paralytic stage looking away from it. In some cases the conjugate deviation is not complete, and the weakness of the recti is manifested by nystagmus.

The second cause of hemiparesis, as described by Macewen, is a downward pressure exerted by the abscess,

which forces the cerebellum into the foramen magnum. The compression of the pyramidal tract induced in this way gives rise to a spastic paresis of the arm and leg on the side of the lesion.

NOTE 6.—*The Removal of the Stapes for the Relief of Auditory Vertigo*. By EUGENE A. CROCKETT, M.D., Boston, Mass. (Reprinted from the *Annals of Otology, Rhinology and Laryngology*, March, 1903.)

In considering the ætiology of auditory vertigo it is evident that a lack of mobility of the base plate of the stapes or of the membrane of the round window must be a primary cause in many cases. Such lack of mobility may be from primary fixation of the stapes, or from the membrana tympani or ossicular chain being rigid, and thus preventing a free motion of the base plate in the oval window. In the second class of cases it would seem that relief of the symptoms under consideration should be obtained by some one of the simpler middle-ear operations, such as removal of the membrane, malleus, and incus (Kessel's or Sexton's method), or removal of the incus alone in the manner so enthusiastically advocated by Burnett. Certainly in some instances marked relief may be obtained by the simple cutting of the intratympanic adhesions or mobilization of the stapes. Where, however, the lesion is primarily about the stapes base plate, no operative measure short of the actual removal of the ossicle will be of any avail, and a consideration of the pathology of this form of ear disease will show us the impossibility of removal of the base plate in advanced cases, owing to the firm cartilaginous or osseous adhesions between the stapes and the edge of the fenestra ovalis.

A considerable experience in middle-ear operations has led the writer to advise such a procedure only as a last resort, and the present operation is advocated only in the severe form of auditory vertigo, and then only when the ordinary treatment has proved futile.

A certain amount of information may be obtained from the consideration of the case history and appearances of each individual case, and particularly on a careful hearing test. For instance, cases showing marked thickening of the membrane, marked retraction of the malleus, with prominence of the posterior fold, or cases where on inspection adhesions can be seen in the tympanum, are more likely to get relief by a simple operation (such as Kessel's) or by the simple cutting of the intratympanic adhesions. Cases where the membrane is normal in appearance and the hearing test shows the trouble to be localized about the base plate of the stapes will, in my opinion, not be benefited by any kind of operation except the removal of the stapes, and this will be particularly difficult, as will be at once seen by a consideration of their pathology. Where, in such cases, a low tone deafness does not rise above middle C in the musical scale and where there is no high-toned deafness or where the upper tone limit is not below 20,000 vibrations a second, the operation of stapedectomy may be undertaken with a fair chance of removing the entire ossicle. Where the upper tone limit is below 20,000 vibrations or the lower limit is above 512 vibrations, the chances are that the anchylosis of the ossicle is so complete that the attempt at its removal will be followed by rupture of the crura at their junction with the base plate, and, of course, in such cases no benefit will result.

Note 7.—*Hearing Tests as an Aid in Locating Tympanic Lesions.*

Hearing tests are used for the purpose of detecting and assisting in the determination of the cause of abnormalities in sound perception or sound transmission in the ear. To be scientifically accurate and commensurate with their purpose they should not only cover the scale limit of the sound-transmitting apparatus of the middle ear, but should provide for tone combinations and for tests of power of accommodation.

In the ordinary course of clinical observation and for practical purposes elaborate investigation is neither necessary nor desirable, and the hearing tests may be confined to a limited number of representative sound sources, it being advisable that these should conform, as nearly as may be possible, to some generally accepted standard and that their record of test may be made to enumerate the individual result as a fraction of a denominational standard.

In the selection of sound sources for the majority of hearing-test purposes it is more important that they should represent, approximately, the upper and lower tone limits and the middle register than the intermediate portions of the normally audible musical scale, and advisable that they should conform, as nearly as possible, to a uniform standard in general use.

The instruments most commonly used for testing the hearing for tones of high pitch are the graduated whistles, of which that of Galton is an example, and the steel rods of Koenig, the former being actuated by means of a blast of air from a rubber bulb, the latter by the blow of a hammer striking midway between the loops by which the

rod is suspended; the original Galton's whistle was not
reliable above a tone of 14,000 simple vibrations in the
second, because the approximation of the plunger to the
upper end of the air chamber at a distance from it equal-
ing the diameter of the chamber constitutes a cubical reso-
nator with a resultant lowering in the pitch of the tone
produced; the improved form of this whistle, modified by
Burkhardt-Merian and Edelmann, gives an upper tone
limit of 84,000 simple vibrations in the second. (Fig. 34.)
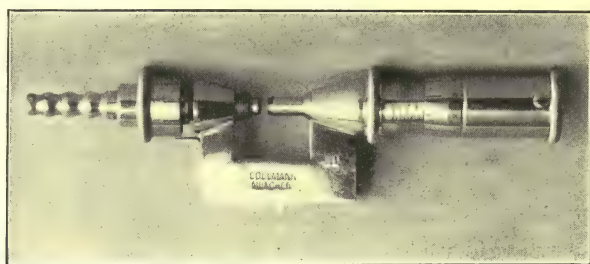
Fig. 34.—The improved Galton whistle.

Watches as hearing tests are open to the objection of
the wide range of difference between their ticking sounds,
both in pitch and in intensity; where the watch is used for
testing purposes it should be fully wound, held always in
the same position with reference to the hand and the per-
son of the observer, and should have been standardized
by testing the distance at which it is heard by a number
of normal ears, that distance being expressed as the de-
nominator in making record.

The differences in the tick of watches have led to the
production of various forms of ticking acoumeters, of
which that of Politzer is the simplest and best. This in-
strument consists of a small steel cylinder struck by a
steel hammer, both being mounted in a vulcanite frame,

with curved end pieces for the reception of the thumb and middle finger, the forefinger being used to lift the hammer, the fall of which, striking the cylinder, gives a
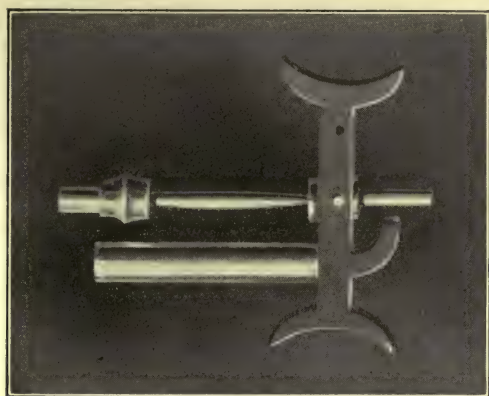
FIG. 35.—Politzer's acoumeter.

sound comparable to the loud tick of a watch, and audible to the normal ear at a distance of fifteen meters. (Fig. 35.)

In testing with this instrument, as with the watch, the opposite ear of the patient should be tightly closed, and care should be taken to avoid reflection of the sound not only from the hand and person of the observer, but from objects in the room in which the test is made, and the instrument should be carried away from the ear in a direct line, slightly in advance of the long axis of the external auditory canal, to a point slightly beyond the greatest distance at which the tick is heard, and then slowly approximated along the same line; the distance at which the tick is again heard being measured and recorded as a fraction of the normal fifteen meters. In testing the hearing for the tick of the acoumeter by bone conduction in cases of a high grade of impairment of hearing for tones

aërially conveyed, or with both ears tightly stopped, the
metal plate mounted on a spindle attached to the vulcanite
frame can be pressed upon the squamous or mastoid sur-
face of the temporal bone.

The ears should be separately tested, and the eyes of
the patient should be kept closed during the test, as the
repeated tick of the acoumeter is a sound which readily
lends itself to the imagination.

Watches and ticking acoumeters are used to test rather
the appreciation of intensity than of pitch in tone percep-
tion, and are quantitatively recorded according to a meas-
ured limit of distance at which they are heard.

Whistles and graded steel rods are used to test the
appreciation of pitch in tone perception, though the whis-
tle, under determinate pressure of its actuating air col-
umn and with a continuous tone, may be used for intensity
tests also; but the instrument best adapted to testing for
tone perception is the tuning fork, because it affords a
tone of definite musical value, having a definite decrease
in intensity from the moment it is set in vibration—unless
constantly actuated, as in the forks kept in vibration by
an electric current—and because it can be used in testing
the hearing power not only through the medium of the
air, but also through the medium of the bones of the head,
the stem of the vibrating tuning fork in the latter test
being touched to the teeth or pressed upon the vertex, the
forehead, or the mastoid process, or elsewhere upon the
head.

The value of the tuning fork as an instrument of pre-
cision, however, is lessened by the fact that not only the
intensity of its tone but also its tone value may be varied
by the means and the force used in setting it in vibration;

if, for instance, an ordinary tuning fork is struck upon a hard substance, there is immediately heard, in addition to the fundamental musical tone which is the characteristic of that particular fork, a number of overtones stronger and sharper in proportion to the force of the blow and the hardness of the substance against which the tuning fork is struck; if the fork is struck against some soft substance, the palm of the hand, for instance, the sharp tones are not made prominent, and only the fundamental tone is heard—varying conditions which in a series of comparative tests afford large margin for error.

To overcome these difficulties two plans have been adopted: one, that of actuating the fork by a blow from a hammer falling through a definite space or moved by a spring of definite strength; the other, that of affixing clamps by means of screws to the tips of the tines of the tuning fork, in order, by the additional weight, to decrease the production of the short sound waves of the overtones or to damp the overtones of the fork by fastening a ring firmly about the lower portions of the tines. Both the falling and the spring hammer have been found to be unreliable for ordinary clinical work, the latter because of the gradual weakening of the spring; and the movable clamps, although they possess the advantage of permitting a change of the tone of the fork within an octave above its fundamental by moving the clamps up and down, are found, in rapid clinical work, to be inconvenient. The French fork, which has its tines inclining toward each other at the tips and which is set in vibration by drawing a stick of wood or bar of metal upward and outward between the tines, though convenient, affords a tone of varying pitch and intensity, according as wood

or metal is used and in proportion to the rapidity with which it is withdrawn.

By making a tuning fork with thin tines weighted at the ends, as represented in Fig. 36, the fork is, of course, less productive of overtones, and by drawing the fork through the fingers, from below upward, the pressure upon the inclined surfaces of the projections forces the tips of the tines together, and the release sets them in vibration with a definite initial excursion.
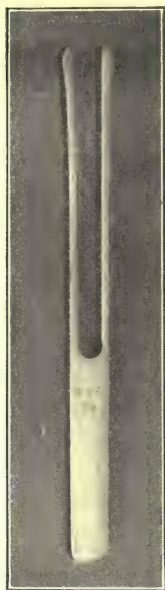
Fig. 36.—Tuning fork improved to lessen overtones and to secure vibrations of definite force.

The best standard fork for general clinical purposes is the physical C 512 vibrations; but in order to make reliable tests it is well to have a series of forks covering a range of at least five octaves, two below and two above the tone mentioned. Standard sets of forks for uniform clinical use are now obtainable, but some of them are more extensive than is requisite for ordinary clinical work, and others are open to the objection of uncertainty in the method of their actuation. A single fork C 512 v. s. of the kind described, if properly balanced, should vibrate audibly to the normal ear from forty-five to sixty seconds, and its normal audible duration of vibration should be determined by repeated tests before it is applied to clinical use.[1]

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[1] These forks, now made by the Harvard Appliance Shop, are carefully tested, both as to pitch and normal duration of audible vibration, and correspondingly marked, before being issued.

In especial tests it is also an advantage to add to this series a second C 512, which, by the boring of a hole one millimeter in diameter transversely through the tip of one of the tines, is adjusted to give beats when sounded in conjunction with the standard fork, a means of test which is sometimes of value in medico-legal as well as in ordinary clinical cases.

In testing with the tuning fork, the tips of the tines, in vibration, should be approximated closely to the meatus, but at a sufficient distance to avoid contact with the fine hairs with which the skin of this portion of the auricle is sometimes beset. After a period of from three to five seconds the fork should be moved to a distance beyond audibility and again, successively, approximated to the meatus at irregular intervals, with the purpose of avoiding the memorizing of the tone, the decrement in intensity of the sound of the fork being greatest in the first twenty-five per cent of its total audible vibration. In testing the hearing by bone conduction the fork is similarly set in vibration, and its butt held gently, but firmly, in contact with the teeth, the bridge of the nose, or any other point upon the head, either in the median line or laterally, as may be desired.

Bone conduction tests made with the tuning fork are either positive with reference to the perception of the sound so conveyed, or relative as compared with the perception of the same sound, by aërial conduction and through the transmitting mechanism of the middle ear.

In the former instance they serve for the gross determination of disorders of the sound-transmitting mechanism of the labyrinth and of the perceptive organ, the exceptions being cases where the labyrinth function is

temporarily abrogated by intralabyrinthine pressure of either intrinsic or extrinsic origin.

In the latter instance they assist in the differential diagnosis between defects in transmission and failure in perception and help toward the localization of the obstruction in the sound-transmitting apparatus.

The various modes of testing, both positive and relative, are usually stated in the literature of this subject under the names of different observers, but may be briefly collated as to their main points.

In cases of monaural impairment of hearing, if the sound of a tuning fork in contact with the head in the median line is heard better in the defective ear, the inference is permissible that there is an obstruction to the passage of sound either in the external canal or the middle ear, and if heard better in the normal ear, that the defective general hearing is due to abnormality of the labyrinthine conducting mechanism or of the perceptive organ.

The sound of a vibrating tuning fork being heard by the normal ear about twice as long, when held opposite the meatus, as when in contact with the mastoid, a decrease in duration of perception aërially and a corresponding increase in duration of perception by bone conduction, permits the inference that this change from the normal relationship is due to abnormality in the sound-transmitting mechanism, a lowering of the duration of perception by both aërial and bone conduction permitting the inference that the perceptive portion of the organ of hearing must be implicated.

The clinical appreciation of exceptions to these rules, incident to pressure abnormalities and to temporary suspense of function, make them only comparatively reliable,

and, in differential diagnosis and the determination of location of obstructions in the sound-transmitting apparatus, the tuning-fork series must be supplemented by other tests and by the objective examination.

The use of the voice as a hearing test should include both speech in the ordinary conversational tone and in a whisper, and the choice of test words and of sentences should be made with reference to the tone pitch and force value of the speech sounds employed.

On account of the wide range of the qualitative values of its component parts and their relative influence upon each other in a spoken sentence, the speech test, as contradistinguished from tests with such instruments of precision as whistles and tuning forks, should be regarded as comparative rather than as absolute, its value consisting especially in the fact that the perception of human speech is, practically, the most important use of the organ of hearing.

Ordinary human speech has an average range of about eight octaves in the musical scale, the deep-toned R representing the lowest and the hissing S the highest limit in this scale. Certain of the consonant checks, R, B, K, T, F, S, and the soft G, have definite intrinsic tones, while others partially borrow their tones or are modified by different degrees of resonance in the nasopharyngeal and nasal cavities; the force value of the consonantal checks and their relation to the carrying power of the intermediate vowel sounds also having an influence upon their audibility.

The comparative force value of the consonant sounds, as determined by logographic curves and by the measured excursions of telephone disks, is represented in the follow-

23

ing table, in which T, as the consonant having the greatest force value, is rated at 100, and the others in comparative proportion:

T	100	S	40
Z	63	F	35
C, hard	62	K, soft	31
P	58	L	21
G	56	N	11
B	53	M	9
D	45		

Words containing the vowel sounds A, E, and I are more readily heard than those compounded with the vowel sounds O and U, and words containing the hard-sounding sharply accentuated consonant checks, K and T, for instance, than those containing consonant sounds which are tone borrowers, and resonance consonants, such as L, M, and N. In testing with single words it will frequently be found that the patient will repeat, as having heard, instead of the soft consonant sound used, the hard consonant sound of corresponding form, as d for l in the word log, which would have been heard had it been used.

In addition to the test which may be made in ordinary conversation, the words of a sentence being so chosen as to represent the range of consonant sounds without impairing the sense, single words in varying series and order of succession should be employed, preferably beginning with monosyllables made up of two representative consonants with an intermediate vowel, such as dog, house, long, land, floor, roof, rug, chair, this, glass, round, ship, chip, cat.

The ears should be tested separately, one ear being stopped, the eyes closed and the patient required to repeat

each word as heard; after this test polysyllabic words should be used and the whole test repeated, with successional variations, in a whisper.

In using both the ordinary conversation tone and the whisper care should be taken to enunciate clearly and to preserve an even, unaccented tone, and the distances at which the test words are accurately heard should be recorded; such a record, together with a memorandum of the consonant substitution on the part of the patient, making a fairly comparative representation of the hearing effect for speech.

In cases of high grades of impairment of hearing the same tests may be, monaurally, made by speaking through a paper tube, an ordinary stiff brown paper mailing tube, two inches in diameter, with a wad of loose wool inserted to break up its resonance, one end of the tube being in contact with the auricle of the patient and the other with the mouth of the speaker.

For ordinary clinical use, in the great majority of cases, the tests with the ticking acoumeter, the improved whistle, a medium- and a low-pitched tuning fork, and the spoken and whispered voice will suffice, but for more accurate determination, in complex cases, and for minute differential diagnosis, a wide range of tuning forks will be required.

APPLICATION OF TESTS

The application of hearing tests, however extensively and carefully made, is of clinical value for diagnostic purposes only when taken in conjunction with the other examinations in the individual case.

Sound waves find access to the organ of hearing

through the medium of the air (aërial conduction) and through the medium of the bones of the head (bone conduction).

The perception of sound waves conveyed aërially may be tested by means of any sound-producing source, but preferably by sources which have a defined value and are standardized—acoumeters, whistles, and tuning forks, for example; the perception of sound waves by bone conduction is best tested by means of tuning forks.

By the individual tests through these media, and also by comparisons made between them, deductions may be drawn as to the location of the lesion which has manifested itself in an impairment of hearing.

The normal sound-transmitting apparatus of the middle ear being capable of transmitting sounds through a range from the lowest audible tone to a tone of from 45,000 to 50,000 vibrations per second, and the perceptive apparatus having a capacity up to 100,000 vibrations per second or higher, the diagnostic value of tones of high pitch, aërially conveyed, is based upon the following premises: that the limit of the perceptive power exceeds the limit of the middle-ear transmission under normal conditions; that the structures of the middle ear present, therefore, in their normal condition a barrier to the passage of sonorous vibrations above a given point; that, the perceptive power of the ear being normal, morbid changes in the middle ear result in a variation in the limit of the transmission of musical tones. Increase in the upper tone limit, as tested by high-pitched musical tones, is found under voluntary contraction of the tensor tympani muscle, under moderately increased tension of the sound-transmitting apparatus as a whole,

under transmission of the vibration of the posterior segment of the drumhead directly to the descending process of the incus, either by contact or through the medium of cicatrices and adhesions, and under conditions of perforation of the drumhead, either surgically or pathologically made, which permit direct access to a mobile stapes.

A corresponding decrease in the upper tone limit is found under increased tension of the middle-ear sound-transmitting apparatus to the extent of obstructive fixation; under conditions inhibiting its movement, such as articular changes, swelling of the tympanic mucous membrane and accumulation of fluid in the middle ear in acute and general thickening of the mucous and submucous tissues in chronic, nonsuppurative cases, and in bony fixation of the stapes; in cases of suppurative disease, with perforation of the drumhead, such obstructions to the passage of sound waves or limitations of the movement of the stapes as are furnished by engorgement of the lining membrane, synechiæ, adhesions, and the presence of epidermal accumulations, granulomata, and secretion.

In cases of facial paralysis the test with tones of high pitch may sometimes assist in locating the seat of lesion; if this location is below the offset of the twig to the stapedius muscle, and the middle ear is normal, there will be no alteration in the upper tone limit; if above this point, the consequent inhibition of the stapedius muscle will permit an increase in tension of the sound-transmitting apparatus by the uncounteracted contraction of the tensor tympani muscle, resulting in an extension of the upper tone limit.

The tests for variations in the lower tone limit by sounds aërially conveyed, while comparatively valuable in

the determination of interference conditions, are subject to the disadvantages incident to the fact that vibrations of greater amplitude are readily translatable to the perceptive organ through other media than the sound-transmitting apparatus, and they are therefore of more value when their results are considered in conjunction with the results of tests of the upper tone limits.

Aërial hearing for tones of low pitch may be decreased by relaxation of the posterior segment of the drumhead, by the presence of relaxed cicatrices, and by general interference with sound transmission in the middle ear, especially in the region of the stapes and of the round window. Decreased hearing for tones of low and medium pitch may also occur, as a fatigue symptom, in various neuroses.

In the differential diagnosis between conditions affecting sound transmission and sound perception a comparison between the results obtained by aërial and by bone-conduction tests is important.

In monaural impairment of hearing, if the sound of a vibrating tuning fork, placed with its butt on the median line of the head, is heard better in the affected ear, the assumption is permissible that the perceptive apparatus on that side is intact, and that the defective hearing, aërially, is due to some obstruction in the sound-transmitting apparatus.

In binaural impairment of hearing this test is of less value for differential diagnosis than when one ear is normal, and its conclusions are open to such exceptions as occur with suspense of labyrinth function consequent upon middle-ear changes and the temporary abrogation of function occurring in hysteria and allied neuroses.

When the tuning fork is heard, by bone conduction, from the median line mainly or solely in the hearing ear, the assumption is permissible that the impairment or loss of hearing in the affected ear is due to intralabyrinthine or intracranial changes or to a temporary abrogation of function.

Testing by the tuning fork for duration of hearing, both aërially and by bone conduction, presupposes the use of a fork the normal audible duration of which has been determined by repeated tests with apparently normal ears, the method sometimes employed of making comparison with the duration of hearing of the observer constituting a standard of uncertain value. In testing it should also be had in mind that on the average more than fifty per cent of the intensity of the tone of the fork, actuated by a single blow or by compression of its tines, is lost in the first third of its duration of audible vibration.

Since in the normal ear the sound of a tuning fork, aërially conveyed to the middle ear, is better and longer heard than when the sound is conveyed through the cranial bones, a measure for comparison is afforded, the duration for hearing of the same fork, with its butt placed upon the mastoid, being on the average about fifty-five per cent of the duration of hearing for the fork with the tips of its tines held opposite the meatus.

This experiment of Weber, when taken in conjunction with the preceding test of Rinne, affords for clinical uses a gross determination of comparison between the effects of changes in the sound-transmitting apparatus and in the perceptive organ upon the function of hearing. For all such tests the medium pitched fork (512 v. s.) of pro-

longed audible duration (forty-five to sixty-five seconds) usually suffices, and is preferable to forks of higher pitch.

To these tests may be added, as control tests, the entotic tests of Politzer and Bing—sound conveyed through the tympanopharyngeal tube by means of a catheter— and the pressure test of Gellé, in which the tension of the sound-transmitting apparatus is varied by condensation and rarefaction of the air in the external auditory canal coincidently with the perception of the sound of a tuning fork by bone conduction, condensation of the air decreasing the tuning-fork perception in the normal ear by increasing intralabyrinthine pressure; this effect is wanting when there is fixation of the stapes, and remains when there is decrease of hearing from intralabyrinthine causes, the stapes remaining mobile. Gellé's test is valuable only in the higher grades of impairment of hearing.

Despite the attention which has been given to the differential diagnosis of causative factors in the impairment of hearing and their location in the sound-transmitting or sound-perceiving portions of the auditory apparatus, there is no field of otological research which offers so large an opportunity for control investigation.

The transmission capacity of different portions of the cranium, the degree of participation of the sound-transmitting mechanism of the middle ear in the conduction to the labyrinth of sounds conveyed through the bones of the head, and, in cases of monaural impairment or loss of hearing, the symptom-effect of translation of sounds to the unaffected ear, are among the questions still awaiting a final decision, which can be arrived at only by the compilation of the results of extended observations.

NOTE 8.—*Surgical Exploration of the Labyrinth after the Method of Julien Bourguet.* (Abstract and illustrations from *Annales des Maladies de L'Oreille, du Larynx, du Nez et du Pharynx,* Paris, September 1905, vol. xxxi, No. 9.)

After a thorough review of other methods of performing this operation, Bourguet describes his own technique,

FIG. 37.—Facial nerve protector for use in labyrinthine operation.

using a special instrument which he has devised to limit the dangers to the facial nerve. This instrument (Fig. 37) acts as a guide for the opening into the labyrinth and a protector for the nerve. It consists of a small semilunar plate fixed at an obtuse angle to a curved stem, like that of Stacke's protector, fitted to the curve of the external auditory canal. At the level of its base the plate is provided with a heel of three millimeters in
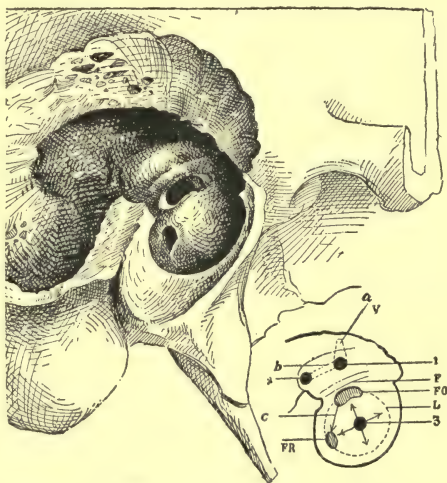
FIG. 38.—The large figure shows the internal wall of antrum and tympanum after extensive exenteration. The small figure shows by dotted lines the trephine areas. 1, opening into upper part of vestibule; 2, external semicircular canal; 3, opening into promontory; *F,* facial canal; *FO,* oval window; *FR,* round window.

length by two millimeters in width, which is intended to engage in the vestibule across the oval window. The superior face of the heel and the posterior surface of the plate, which has a height of three millimeters, present a concavity that embraces the external wall of the facial canal as it passes over the oval window.

Having performed the complete mastoido-tympanal exenteration in the usual way, the external opening in the cortex is considerably enlarged to afford a thorough inspection of the internal tympanic wall, under bright illumination (Fig. 38). The footplate of the stapes should be removed completely and the protector introduced, its heel entering the oval window (Fig. 39). Resting the chisel in the concavity of the protector's plate, the bony covering of the anterior branch of the external semicircular canal can be easily entered by a few rotary movements; if protector and chisel be held firmly, the cutting edge cannot slip and wound the nerve, which is well covered by the three millimeters of steel plate. This perforation can be enlarged upward until the superior semicircular canal
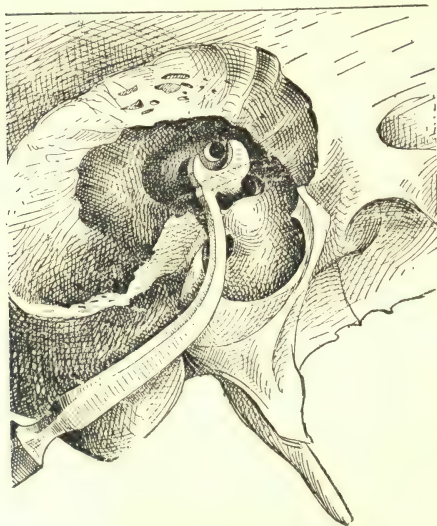
Fig. 39.—The protector in place, preserving the facial nerve, which is indicated by the dotted lines.

is opened also, and, removing the protector, a horizontal canal may be chiseled posteriorly to complete the expo-

sure of the vestibule into the posterior branch of the
external semicircular canal. With the protector again re-
placed and operating
this time under its heel,
the oval and round win-
dows may be connect-
ed by removing the in-
tervening bone, with-
out risk of injuring
the facial nerve in its
downward course. The
cochlea has thus been
invaded, and the oper-
ation is concluded by
removal of the prom-
ontory. As this bone
is removed anteriorly,
caution is necessary to

Fig. 40.—Completed operation; the internal
ear fully exposed.

avoid the carotid artery, which occasionally encroaches
upon the cochlea. The opening should not extend beyond
the tympanic level of the orifice of the tympanopharyn-
geal tube. The completed operation wound is shown in
Fig. 40.

INDEX

351

(1)

THE END

DISEASES OF THE EAR

By EDWARD BRADFORD DENCH, Ph.B., M.D.

Professor of Otology in the University and Bellevue Hospital Medical College ;
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